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Great Lakes Water Quality Third Annual Report 1974: Appendix B: Annual Report of the Surveillance Subcommittee to the Implementation Committee, Great Lakes Water Quality Board

Great Lakes Water Quality Board. Surveillance SubCommittee

GREAT LAKES
WATER QUALITY BOARD

INTERNATIONAL JOINT COMMISSION

GREAT LAKES WATER QUALITY 1974

APPENDIX B

SURVEILLANCE SUBCOMMITTEE REPORT

GREAT LAKES WATER QUALITY
THIRD ANNUAL REPORT

APPENDIX B

ANNUAL REPORT OF THE SURVEILLANCE SUBCOMMITTEE

TO THE IMPLEMENTATION COMMITTEE
GREAT LAKES WATER QUALITY BOARD
JUNE 1975

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PREFACE

This Appendix to the 1974 Annual Report on Great Lakes Water Quality is the report of the Surveillance Subcommittee submitted to the Implementation Committee and the Great Lakes Water Quality Board. The Appendix contains the detailed information and data with respect to water quality in the Great Lakes and Connecting Channels as well as the detailed surveillance program developed by the Subcommittee for the Boards' Third Annual Report to the International Joint Commission.

The Board has reviewed and approved the Subcommittee's report for publication as an Appendix to its report. However, some of the specific conclusions and recommendations contained in this Appendix may not be supported by the Board in its 1974 Annual Report to the International Joint Commission.

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CONCLUSIONS AND RECOMMENDATIONS

1. A general assessment of Lakes Ontario, Huron, Michigan Superior, and the interconnecting channels including the St. Lawrence River, the Niagara River and the St. Mary's River is presented in the General Assessment Section, following. Previously known and new problem areas are listed with indications of change and the existence or non existence of plans to remedy the problems.

2. Persistent contaminant information has been reviewed, revealing problems with the release, exchange and central storage of such data. Problems are also encountered in the interpretation of the data since sampling and analytical methodologies are not comparable for the various sets of data available. Data for time trend analysis is lacking. The Surveillance Subcommittee strongly supports efforts to consolidate existing information and to develop a suitable surveillance program for contaminants in the fish populations of the Great Lakes.

3. Tables summarizing loading data reported by the jurisdictions are included in the Appendix. The adequacy of some of this data is questioned and it is recommended that existing efforts to improve the reliability and compatibility of the loading estimates should be continued and extended by all jurisdictions and agencies.

4. A detailed assessment is presented for the St. Clair, Detroit River System, and for Lake Erie. Here, violations of IJC water quality objectives have been documented for bacteriological quality and pH. Reductions in total dissolved solids and chloride concentrations in Lake Erie are related essentially to dilution due to increased flowthrough with virtually constant loading over the past 5 to 10 years. In the event of continued fixed loadings at present levels, average TDS in the eastern and central basins will hover close to the IJC objective (200 mg/l) and exceed it in periods of low flow. Some evidence for the impact of phosphorus control is apparent in lower P concentrations in the western basin of Lake Erie, while only weak evidence exists for biomass reductions in the open lake west end, with no discernible change in the eastern and central basins.

   Dissolved oxygen depletion rates have apparently stabilized and the areal extent of hypolimnetic oxygen depletion in the central basin is near the maximum possible. This has continued to worsen since 1967, but has reached its limit <u>in this central basin</u>. With this, has continued the deterioration in the bottom fauna situation. The dissolved oxygen and related problems will be the slowest to respond to phosphorus loading reductions by virtue of the time that it takes to flush the lake by flowthrough and the yearly regeneration of phosphorus from bottom sediments in the anoxic summer conditions and in severe storms. It is too soon to see improvement in these parameters.

Improvements are being found in zones close to sources that have been cleaned up. An example of this is the improvement documented for bacteriological conditions on beaches on the south shore of Lake Erie.

5. We recommend the Surveillance Program Design outlined in this report as an interim design subject to major review within the next two years as a number of technical studies designed to resolve problems of assigning sampling frequency of known efficacy are completed and applied.

6. We recommend the cost estimates presented in the report as a general guideline for funding to maintain a desirable surveillance program until detailed cost estimates, jurisdiction responsibilities and final surveillance program design is worked out.

7. We recommend heavy emphasis on refinement of loading estimates for phosphorus through major tributaries and interconnecting channels, through municipal and industrial outfalls and from the atmosphere (where significant). This is reflected in a special study undertaken for the Detroit River and our support of studies initiated by the U.S. Buffalo Corps of Engineers and planned by the Pollution from Land Use Activities Reference Group. In addition we support the proposed verification study for municipal sources, presented to the Water Quality Board on March 4-5, 1975.

8. We recommend immediate involvement of all jurisdictions and laboratories in the job of assuring data quality for information to be included in IJC reports.

9. We recommend, in view of the urgent need for a combined data base for physical, chemical and biological water quality data, that a separate working group composed of persons cognizant of data management systems, be established by the Data Quality Subcommittee for the purpose of addressing the data processing problem. In view of the Surveillance Subcommittee concerns that the combined data base be established by December 31, 1975, we further recommend that the group be brought together as soon as possible and report directly to our Subcommittee.

GENERAL ASSESSMENT OF WATER QUALITY

The Surveillance Subcommittee, after review of the scope and effort involved in reporting on water quality conditions in the Great Lakes System, has concluded that its annual report to the Implementation Committee for 1974 should include analysis of the information at two levels of intensity.

The first level is that of a general assessment of water quality and loadings to all parts of the system. This is to identify problem areas, and to provide an annual summary of estimates of loadings of phosphorous, B.O.D. and suspended solids from municipalities, industry, tributaries and connecting channels.

The second level is that of a detailed assessment of some particular lake and connecting channel. This detailed assessment, while it contains identification of problem areas, is to address particularly the matter of time trends in the lake conditions and an assessment of whether the conditions are improving or not. In accordance with the schedule drawn up for detailed assessments in annual reports, Lake Erie and the St. Clair River - Lake St. Clair - Detroit River System are addressed in great detail in the next section of the reports.

GREAT LAKES

Lake Superior

From May to November 1973, six cruises were made to establish baseline bacteriological levels as part of the Upper Lakes Reference Group Study. Some monthly trends were observed in the coastal areas. Coliform densities increased throughout the sampling period. Fecal coliform populations fluctuated with peaks in May, July-August and November, and fecal streptococcus population densities decreased slightly from May-November. Maximum heterotrophic bacterial populations occurred during the July-August period.

On a Lake-wide basis, coliforms increased to maximum levels during the September-October period and dropped during November to the levels found in the spring season. Fecal coliform, fecal streptococcus and heterotrophic bacterial populations exhibited trends similar to those observed in the coastal areas. At least 85% of the analyzed water samples showed fecal coliform and fecal streptococcus populations less than 1 per 100 ml.

From the data collected, implications are that the present water quality of the Lake is good and that the main body is free from detectable fecal contamination.[1]

[1] Rao, S.S. and Henderson, J. Summary Report of Microbiological Baseline Data on Lake Superior, 1973. Scientific Series No. 45, Inland Waters Directorate, Canada Centre for Inland Waters, Burlington, Ontario: 1974.

Nearshore problem areas have been indicated by the various jurisdictions, which include the Duluth-Superior Harbors and pollution from the St. Louis River Watershed as well as shoreline erosion of red clay bluffs on the U.S. side of Lake Superior. Red clay areas were identified from Duluth-Superior Harbors along the shore to Sand Point at a distance up to five miles from shore and in Chequamegon Bay along the shoreline from Chequamegon Point to the Montreal River. These areas and the areas at the mouths of tributaries which flow through the red clay deposits are characterized by increased suspended solids and turbidity. The continuing discharge of taconite tailings from the Reserve Mining plant at Silver Bay remains a serious pollution problem, but this subject is discussed in detail in the Asbestos report previously submitted to the International Joint Commission and therefore is not repeated here.

Presently water quality conditions in the St. Louis River are periodically in violation of Minnesota standards. The discharge of settleable waste materials from municipal, industrial and natural sources for many years has resulted in extensive sludge deposits. Oxygen uptake by sludge deposits, excessive BOD concentrations and high coliform counts create a significant pollution problem.

Industrial and municipal sources of wastewater on the St. Louis River Watershed are the primary sources of pollution problems in Duluth-Superior Harbor. The completion of the Western Lake Superior Sanitary District Treatment facility in mid, 1977 should significantly improve the water quality of the St. Louis River. Harbor dredging activities and discharges of shipping wastes impact water quality in the shipping channel and open lake disposal areas, at varying rates and at irregular intervals. Natural (non-point) sources and bottom sludges contribute heavily to the problem of low dissolved oxygen in the lower sections of the Bay area. These sources will continue to have an impact on the river even if point sources are abated.

Untreated wastes from harbor traffic is a significant source of pollution. Wastes discharged from commercial vessels include sanitary wastes, waste bilge water and contaminated ballast water. Significant volumes of these untreated wastes have been dumped in St. Louis Bay and Superior Bay. Recreational craft also dispose of untreated sanitary wastes and bilge water.

In Thunder Bay, Ontario, samples collected during surveys in June and October 1974 showed total and fecal coliform levels were essentially unchanged from 1973. The June survey exhibited the greatest areal extent of non-compliance with the Agreement objectives. Total coliform levels in the excess of 1,000 per 100 ml and fecal coliform counts in excess of 200 per 100 ml existed behind the harbor breakwall and out to about one mile off shore of the Kaministikwia River as far south as Mission Bay.

Lake Michigan

Michigan State's Great Lake nearshore water quality was examined using data obtained during the 1974 Water Intake Monitoring Program based on annual samples. The only objective not met was total coliform for nine intakes. Two of these intakes, the Escanaba Water Works and the Holland Water Works are identified for Lake Michigan where the total coliforms/100 ml were reported as 2,900 and 4,700 respectively.

Two areas which are considered to present water quality problems within the Wisconsin jurisdiction are Green Bay in an area southeast of the navigation channel and south of the northern Brown County Line and Milwaukee Harbor in an area within the harbor breakwater. The Milwaukee Harbor area is affected by non-point inputs, largely urban and urbanizing runoff effects. Generally the Lower Green Bay has been identified as a polluted area being influenced by the highly industrialized and populous Fox River Valley. In general, the open lake waters in the Wisconsin portion of Lake Michigan are of high quality showing only minor effects of municipal and industrial inputs.

A detailed report of the Wisconsin Department of Natural Resources, sponsored by the U.S. Environmental Protection Agency provides an assessment of environmental conditions within Lower Green Bay.

The change in nutrient loadings to Green Bay over the past thirty or forty years is difficult to document because of the paucity of data. The resulting algae growth has always been a part of the recorded history of Green Bay and may be associated with the origin of its name. In the recent two or three years the total algae growth may not have varied greatly but its extent and local concentration appear to have varied.

The Lower Fox River remains the largest source of nutrients and wastes for Green Bay. During the past twenty years pulp and paper production for mills along this river have approximately doubled. The BOD_5 and suspended solids discharges from these mills are now approximately what they were twenty years ago after an intermediate period of higher loadings. BOD_5 loadings from sewage treatment plants have risen in the past ten years along the Lower Fox River.

Investigations of the type of bottom sediment in Green Bay show that an area at the extreme lower end of the Bay contains a high content of sewage sludge, derived from a combination of the inflowing Fox River and the outfall of the Green Bay sewage treatment plant. Brown silt was found to be common northeast of Long Tail Point and along the eastern shore. Brown mud, more cohesive than silt or the semifluid mud of the lower Bay, occured in the deeper water further north in the Bay. Data were interpreted to indicate that Green Bay was filling in at a rate of 10 to 100 times that associated with larger bodies of water.

A historic change in the species composition of the commercial fish catch has occurred in Green Bay as well as in the Great Lakes in general. The early fishery (circa 1900) consisted of lake trout, white fish, lake herring, chubs, walleye and sturgeon. The present major commercial species are carp, smelt, alewife and perch. This represents a shift from high quality native species to low quality species.

Dissolved oxygen concentrations in Green Bay appear to have decreased in the past thirty years. During warm weather, critical dissolved oxygen conditions are common on the Fox River and for a distance of 3-5 km into the Bay. In the colder months (from about mid-November into April), the dissolved oxygen in the river is generally in excess of 5 mg/l. However, during the winter and particularly after prolonged heavy ice cover, low dissolved oxygen concentrations can extend into Green Bay for distances of nearly 50 km. During the period of open water, reaeration causes a recovery of oxygen levels beyond the Long Tail Point area.[2]

[2] Lower Green Bay - An Evaluation of Existing and Historical Conditions, the Wisconsin Department of Natural Resources. U.S. Environmental Protection Agency, Region V Enforcement Division, Great Lakes Initiative Contract Program, August, 1974.

The Indiana report for 1973 included information from water intakes to the lake proper at East Chicago, Gary and Michigan City sampled on a biweekly basis. It was stressed that data for intakes may not be representative for the quality of the lake in general; however, these data should provide information regarding certain trends. A downward trend in oil concentrations was evident when data was compared for 1972 and 1970. Dissolved oxygen values for 1973, while not meeting an 80% saturation criterion at all times, did not fall below the present IJC objective of 6.0 mg/l at any of the intakes. Ammonia nitrogen failed to meet the state criterion at all intakes. Phenol data in 1973 indicated a marked improvement over the 1972 results. Cadmium analysis indicated only one violation each year for 1972 and 1973 at East Chicago. In 1973 6% of the samples at East Chicago and at Gary failed to meet the State criterion of 0.05 mg/l for lead. Data provided for the first half of 1974 indicated that results of analyses are similar to those reported in 1973.

Data were also provided for two intakes (Hammond and Whiting) to indicate conditions in the Inner Harbor Basin. Results are similar to those presented for the open lake waters. Ammonia levels were still at somewhat elevated levels and no trends were indicated. Oil levels at Whiting were similar but levels at Hammond appear to have dropped based on the average level of 2.9 mg/l for the first half of 1974. Phenol remains at the low levels reported for 1973. Fecal coliform appear to meet the state criterion on all samples.

It was reported for 1973 that the condition of Indiana tributaries to Lake Michigan, particularly the Indiana Ship Harbor Canal was much improved, however, the established general State criteria were not met at all times.

The problems associated with the Indiana Ship Harbor Canal are further detailed in a report of the ITT Research Institute under contract to the U.S. Environmental Protection Agency concerning a water pollution investigation in the Calumet Area of Lake Michigan.

The report indicates the main source of pollution in the area (extending from the 68th St. Crib of the Chicago Water Dept. to Burns Ditch in Indiana) is the Indiana Ship Harbor Canal, which carries effluents from the major steel mills, refineries and municipal sewage treatment plants into the Lake. Concentrations exceeding State water quality standards were measured as far as five miles from shore, particularly for ammonia-nitrogen and bacteria. High chlorophyll measurements showed that the Indiana Ship Harbor Canal effluent has a nutrient effect on algae growth.

The most noticeable pollutants are ammonia-nitrogen and phosphorus. It was noted, however that phosphorus effluents decreased 40% during the four years previous to the report due to improved treatment by Indiana municipalities and phosphorus limitation on detergents in Indiana. An increasing trend of phosphorus at the 68th St. Crib was apparent for 16 years but a 20% decrease was evident in the two years previous to the report.

Other pollutants are suspended iron, which causes a colored plume, and oil and phenol from steel mills and refineries which cause unpleasant tastes in local water supplies, and require extensive use of carbon for municipal water treatment. Oil causes surface slicks that dirty pleasure boats. This oil and other organic pollutants shift aquatic life towards species that usually live in polluted waters.

Bacterial pollution from the Indiana Ship Harbor Canal remained high, due to delays in municipal treatment construction and diversion of industrial effluents to the municipal plants.[3]

Data that are currently available from the Great Lakes Environmental Contaminants Survey for PCB levels indicate during 1972 and 1973, levels in coho salmon and lake trout have been two to four times the FDA action level and chubs have been at or slightly over the 5 ppm level. Currently, there is insufficient data to indicate any definite trend, although it appears there is no significant change from 1972 to 1973. PCB levels in open lake waters are generally below detectable limits.

A Federal-State Interagency Surveillance Program is being developed to identify point sources of PCB's in the Lake Michigan Basin.

The Federal Drug Administration has stated that interstate chipments of fish from Lake Michigan will be confiscated for exceeding F.D.A. standards for PCB's.

[3] Richard H. Snow. IIT Research Institute. Water Pollution Investigation: Calument Area of Lake Michigan. U.S. Environmental Protection Agency, Region V. Vol. 1, October 1974.

Lake Huron

Under the Water Intake Monitoring Program of Michigan, two intakes, namely the Pinconning Water Works and the Bay City Water Works, appeared not to be in compliance for total coliforms. The counts reported were 2,200 and 1,500 coliforms per 100 ml. respectively; however, it must be borne in mind that this assessment is based upon an annual sample.

Water quality conditions for Saginaw Bay of Lake Huron were reported in April of 1974 by the University of Michigan. The following paragraphs indicate the findings outlined in the summary of that report.

"The water quality in Saginaw Bay has deteriorated from its natural Lake Huron character through man's overburdening use. Both the physical-chemical and biological characteristics indicate similar conditions and trends.

Chemically Saginaw Bay is blighted by high concentrations of dissolved solids originating from the Saginaw River system. Concentrations are generally higher in the inner bay. A decreasing gradient exists outward as the Lake Huron water dilutes their content. Distributions of the concentrating ions in bay surface waters tend to follow the flow of the contaminating Saginaw River as it is guided into the inner bay over fivefold those of the background Lake Huron values.

Excessive nutrient concentrations are also characteristic of Saginaw Bay. Both nitrogen and phosphorous are in sufficient levels to support prolific growths of algae. Total phosphorous concentrations are over four times those of Lake Huron. The distribution of phosphorus suggests significant sources of runoff from all land areas surrounding the bay and interaction with the sediments in the shallower waters.

Chemically, the system's major contaminant source is the Saginaw River. Other tributary and industrial sources add what is usually considered to be minor contamination, except in the local environment. Questions now arise as to the significance of other sources with regard to nutrient concentrations.

The biologic communities of Saginaw Bay also are indicative of poor water quality.

Overall, the benthic fauna of the bay indicate decreased environmental quality, particularly in the inner bay. Indicative evidence includes the increase in oligochaete predominance, the decrease in clean water types, and the disappearance of the once common mayfly population.

Saginaw Bay's fish community has also been heavily altered, particularly in the last half century. The commercial fishing industry has been severely curtailed. Species composition has changed dramatically to low value fish, and fish production has steadily decreased to its present low. Causes for these changes include changes in the foodweb, predation and competition from invading marine sea lamprey and alewives, changes in habitat, commercial fishing exploitation, and changes in water quality.

Phytoplankton concentrations are eight times the value normally found in Lake Huron, while carbon fixation rates were fifteen to thirty times greater.

Numerous other serious problems exist in the bay but are not quantitatively documented by water-quality data. The problem of siltation has continually been termed severe and the associated problems of turbidity and sediment deposition affect water quality. The list of causative factors includes river and bay dredging, shoreline erosion, excessive algal growths, wind deposition of soils, and wave action churning up the sediments.

Thermal enrichment is also considered by many to be a potential problem. Disruption or destruction of the normal biological cycles is feared and adverse effects have already been noted in localized areas.

Occasional oil and chemical spills have been reported resulting in fish and wildlife mortality and fish tainting.

Water Supply problems have also been realized. Filter clogging, taste and odor, and corrosion are among the major concerns."[4]

Three problem areas were identified by the Ministry of the Environment for Lake Huron in which water quality objectives are not met. Penetang and Midland Bays are affected by phosphorus and resulting Cladophora levels.

[4] Paul L. Freeman. Saginaw Bay: An Evaluation of Existing and Historical Conditions. The University of Michigan. U.S. EPA Environmental Protection Agency, Region V, April, 1974.

Chlorophyll levels in the waters of Penetang Bay are comparable to those of Western Lake Erie. Both Penetang Bay and, to a lesser degree Midland Bay, are sensitive to the nutrient inputs and support luxurious Cladophora growths close to sources.

The North Channel is subject to a tributary input carrying treated Kraft Mill wastes which are believed to contribute to reported incidents of objectionable taste in fish taken in the vicinity of the Spanish River mouth.

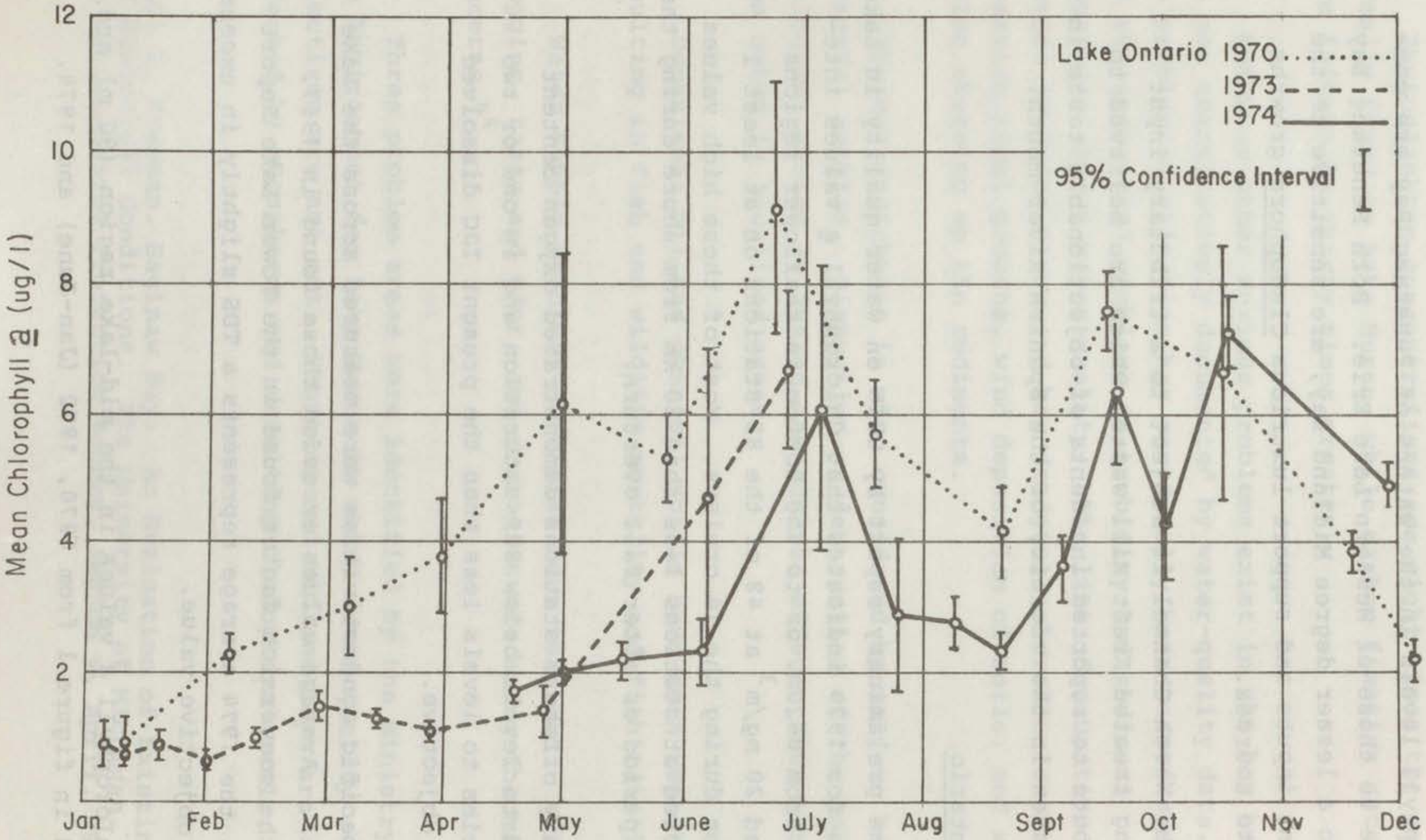
Lake Ontario

The preliminary report by CCIW on water quality in Lake Ontario for 1974 indicates that Chlorophyll a values integrated from 0-20m. or to the bottom in shallower regions exceeded 20 mg/m^3 at 48 of the 85 stations on at least 1 occasion during the 14 cruises. Most of these high values were noted at stations less than 20 km from shore during the spring period or after fall overturn.

Many offshore stations demonstrated oxygen content reduced to levels below 80% saturation and in one or two localities to levels less than the present IJC dissolved oxygen objective.

Specific conductivities were measured across the Lake in April. Average values exceeded those found in 1967. Using the conversion factor found in the Lower Lake Report (0.62), the 1974 average represents a TDS slightly in excess of the objective value.

Chlorophyll a values in the mid-lake region (80 m) are plotted in figure 1 from 1970, 1972 (Jan-June) and 1974.



LAKE ONTARIO MIDLAKE MEAN CHLOROPHYLL a 1970-1974

Figure 1

The 1974 values seem to differ significantly from those in 1970 which were generally higher at any particular time. Differences in the remainder of the lake are less clear although the data have not been analyzed region by region. It is too early to say whether these yearly differences represent a trend or to conjecture to what one might ascribe the differences. It should be noted that despite the ameliorated conditions of biomass standing stock conditions observed, bottom oxygen conditions would seem to be less favourable in 1974 than previous years. This is difficult to assess because of less adequate coverage of this parameter in space and time in 1970 and 1972.

In summary the 1974 pilot program for Lake Ontario has demonstrated a seasonal pattern of chlorophyll a concentration which appears to differ from 1970. Apparently, there was less phytoplankton biomass in the lake in 1974. Conversly there appeared to be more localities where bottom oxygen concentrations were less than in 1970. Conductivity measurements indicate that the total dissolved solids concentration is at or above the IJC objective value.

The Ministry of the Environment provided information regarding three areas in which various water quality objectives are not met.

Hamilton Harbour was listed as an area in which dissolved oxygen, iron, heavy metals, coliforms, PCB's and phosphorus generally exceed objectives. Dissolved oxygen levels below 4 mg/l exists in the lower portion of the hypolimnion for large regions of the harbor from July to September except during high wind conditions. It is estimated that approximately two thirds of the deficit is caused by discharges and sediment demand and one third by phytoplankton decay during

August. The levels of total iron exceed the objective of 0.3 mg/l (maximum level recorded of 3.7 mg/l). Most of the iron is suspected to be in the particulate form and therefore is not as critical to domestic supplies. High levels of lead, chromium, cadmium, mercury and iron were reported in harbor sediments. Existing widespread accumulation of iron oxide in sediments is expected to prevent the establishment of a desirable benthic community in the affected areas for many years and will delay rehabilitation of the fish population. The source of the elevated mercury levels in sediments is now closed. Mercury levels in fish have been found to be in compliance with the suggested limit of 0.5 mg/kg. High total and fecal coliform levels have been found in Hamilton Harbour near the outfall of the Water Pollution Control Plant and in the vicinity of major sewer overflows along the south shore. PCB's have been reported in fish taken from the harbor. Levels in predacious fish have been found above the suggested limit of 5ppm. Phosphorus inputs are felt to have been responsible for the eutrophic conditions and resultant algae growth in the bay.

The Bay of Quinte has been reported for excessive levels of total and fecal coliforms near Trenton and Picton at certain times of the year. Because of the shallow depth and enclosed nature of the Bay, the water quality has been sensitive to land drainage and municipal utilities input. Nuisance rooted aquatic growths occur in several sections of the Bay and bathing beaches in the north sustain substantial Cladophora growth. Even with implementation of phosphorus removal at sewage treatment plants, heavy aquatic growth is expected for some time due to natural conditions and slow flushing action coupled with residual inputs from land drainage. Eutrophication caused by nutrient input has also led to taste and odor problems near Kingston and in an area between Trenton and Deseronto due to phytoplankton blooms.

The Toronto Harbour and waterfront were also identified as problem areas. The waterfront is subject to high levels of total and fecal coliforms very close to shore, particularly near the Humber River and in Ashbridges Bay. The harbour exhibits a potential problem through contamination of sediments by heavy metals, especially lead and zinc.

Reports by the New York Department of Environmental Conservation for Lake Ontario indicate that shore waters, in contrast to the generally good quality of the open waters, were affected by pollution from degraded river systems and waste outlets. "Although the oxygen levels and BOD concentrations of the shore waters showed insignificant effects of pollution the M.P.N. values found were indicative of the bacterial defilement by sewage materials. Higher turbidities accompanied by colour were found near the shore in the vicinity of the larger creeks."

Areas have been identified in which the significant problems along the shoreline include high coliform levels, solids and nutrients due to untreated and inadequately treated municipal and industrial wastes.

The municipal centres identified include Youngstown and Niagara Beach, Newfane, Olcott and Rochester. In the Youngstown, Niagara Beach, Newfane and Olcott areas existing treatment is to be upgraded to secondary treatment with phosphate reduction. In the Rochester area the primary sewage treatment plant and raw overflows from combined sewers were replaced by secondary treatment with phosphate reduction.

Eight areas were identified resulting from industrial effects. In the Newfane area, the Carborundum Corporation discharge is to be served by the Newfane Sewer District. Brockport was identified as a source of waste alum sludge and filter backwash waste from the Water Treatment Plant. No plan exists to correct this situation. A similar situation exists for the Milton Water Treatment Plant. The Genesee River (Rochester Harbor area) is subject to suspended and settleable solids from natural soil erosion, storm sewers, and various raw discharges significantly contribute to siltation of the Harbor, requiring periodic dredging. The high organic content of present dredge spoils is expected to be significantly reduced by recently initiated and proposed treatment of existing discharges. The Oswego Harbor area is subject to a significant thermal discharge from NMPC on the west side of the Harbor. Chloride from the Finger Lakes Area will continue to enter the lake via the Oswego River, but no significant buildup has yet occured, nor are problems expected. Nutrient loadings via the Black River have been reduced through abatement of major paper mill discharges. Further reduction is expected within the next few years when the Carthage Paper Company connects into the Carthage Sewage Treatment Plant, the Brownville Paper Company constructs a treatment facility (schedule presently being negotiated) and Watertown upgrades its present primary sewage treatment plant to secondary treatment with phosphate reduction (awaiting funding). The Black River Bay will continue to suffer from nutrient overloads (localized) due to heavy sawdust deposits from old paper mill discharges and periodic runoff from flood-prone farmland in the watershed.

CONNECTING CHANNELS

St. Marys River

The Ministry of the Environment reported parameters of concern which included phenol, cyanide, fecal coliforms and floating material. Phenol levels during 1973 and 1974 were higher than those observed during the period 1968-1972 in response to lower flows prevailing in the river during these years.

Average phenol levels of 33 μg/l were recorded at 1000' downstream from the main trunk sewer of Algoma Steel Company. A consistent value of 22 μg/l was found near the Canadian Shore and extended to Lake George Channel.

Transboundary movement was evident in the Lake George Channel with levels of 10 μg/l prevailing downstream as far as little Lake George. The elevated phenol levels may affect the taste and odour of water supplies and also may taint fish flesh; however no problems have been reported to date.

Cyanide levels below Algoma Steel main trunk sewer and downstream as far as 1.3 miles, at a lateral distance of 400 feet from the Canadian Shore exceed 0.2 mg/l, the permissible level for drinking water supply.

Counts of total coliform found nearby the sewage treatment plant in Sault Ste. Marie, Ontario exceeded the IJC Objectives (1000 org/100 ml) along a longitudinal distance of 0.8 mile and at a transverse distance of 600 feet from the Canadian Shore.

During 1973 and 1974 surveys, mats of oil and wood chip fibers were present downstream from the locks as far as Lake George in the east channel with a lateral distance ranging from 300 to 600 feet from the Canadian Shore.

Niagara River

Major sources of pollution come from industries on the Buffalo River and industries discharging waste directly to the river on the United States side. Few sources of pollution are found along the Canadian portion of the river.

Water quality of the main stream of the river is basically similar to Lake Erie water; however, noticeable changes in water quality do take place along the river bank on the upper river particularly on the United States side.

Although the river serves as a receiving body for a multitude of municipal and industrial discharges, no violations of the dissolved oxygen standards have been reported. Correspondingly, the BOD, total phosphorus and total coliform levels remain generally low for the entire reach of the river.

The two major present sources of pollution of prime interest are phenol and oil.

Phenol data collected since 1967 show little change to date. Recent information shows that the water near the U.S. shore in some areas on the upper river contains phenol which, at times, exceeds 5 µg/l. Significant phenol dischargers are being abated for the six industries which are the principal sources.

Oils continue to cause more obvious damage than any other single pollutant; however, observations indicated a marked improvement since 1967. Significant oil and grease discharges have been curtailed by the majority of oil terminals, refineries and other industries. Accidental spillage continues, but an increased effort by government and industry may be expected to keep oil pollution problems under contol.

St. Lawrence River

New York Department of Environmental Conservation indicated two areas affected by municipal inputs. The primary treatment facilities for Massena and Ogdensburg are to be upgraded to secondary treatment as soon as funding is available. The sole industrial input identified was the high fluoride discharge to the Lower Grass River at Massena from Alcoa Aluminum which should be abated by treatment upgrading within a year.

In addition it was reported the most significant water quality problem facing the St. Lawrence River is the high potential for major spillage of oil and other hazardous materials due to shipping accidents. particularly with extended navigation on the Seaway as proposed. Critical Waterfowl areas and high-use recreational areas are especially susceptible to damage from spillage since experience has shown the difficulty (or impossibility) of efficient containment and clean-up in the swift river currents and narrow Channels of the Thousand Islands area.

The Canada Centre for Inland Waters reported the following information for phosphorus, and fecal coliforms.

Mean total phosphorus concentrations from the three surveys conducted in 1974 were 0.018, 0.028 and 0.019 mg/l respectively for the June, August and October surveys. This seasonal pattern of higher total phosphorus concentrations in mid-summer was also observed in 1973 although not as noticeably as in 1974. The early summer total phosphorus levels in 1974 were not significantly different from the levels found in 1973.

In general geometric mean values of fecal coliform counts were less than 10/100 ml at all the ranges sampled. There was only a single fecal coliform analysis in which the count was greater than 200/100 ml and occurred at a station in Cataraqui Bay in June. Subsequent samplings of the station showed fecal coliform counts well below 200/100 ml.

SIGNIFICANT TRIBUTARIES

Based on past data, or on a flow basis, the jurisdictions have identified significant tributaries throughout the Great Lakes System which are being monitored for one or more of the following reasons:

(A) significant impact on water quality of lakes or connecting channels;

(B) measurement of total loadings to lakes or connecting channels;

(C) monitoring major municipal or industrial point sources discharge to the stream;

(D) continuation of long-term water quality surveillance stations.

These tributaries are identified by basin and agency in the following Table 1. The full report is on file at the Regional Office.

Table 1

SIGNIFICANT TRIBUTARIES FOR Lake Superior	
JURISDICTION	NAME OF RIVER
Minnesota	St. Louis River
Wisconsin	Montreal River Bad River Bois Brule River Nemadji River
Michigan	Ontonagon Tahquamenon Sturgeon Presque Isle Carp Mineral
Ontario	Nipigon River Michipicoten River Kaministikwia River White River Montreal River Pic River Aquasabon Hydro Dam Magpie River Black River Black Sturgeon River Goulais River Batchawana River Agawa River Pigeon River Harmony River Little Pic River McIntyre River

Table 1 cont'd

SIGNIFICANT TRIBUTARIES FOR Lake Michigan	
JURISDICTION	NAME OF RIVER
Wisconsin	Root River Milwaukee River Sheboygan River Manitowoc River West Twin River East Twin River Kewaunee River Fox River Pensaukee River Oconto River Peshtigo River Menomonee River
Indiana	Trail Creek Burns Ditch Indiana Harbor Canal
Michigan	Grand St. Joseph Manistee Muskegon Manistique Kalamazoo Escanaba Pere Marquette Jordan (Charlevoix Co.) White Big Cedar Elk Ford Whitefish Betsie Boardman Big Sable Black (VanBuren Co.)

Table 1 cont'd

SIGNIFICANT TRIBUTARIES FOR Lake Huron - St. Mary's River	
JURISDICTION	NAME OF RIVER
Ontario	French River Spanish River Mississaugi River Muskaka River Severn River Saugeen River Magnetewan River Wanapetti River Nottawasaga River Maitland River Moon River Serpent River Pickerel River Blind River Sauble River Ausable Div. Cut. Thessalon River McCurry Lake Outlet Garden River East Davignon Creek
Michigan	Saginaw Au Sable Cheboygan Thunder Bay Rifle Pine (Mackinac Co.) Au Gres Kawkawlin

SIGNIFICANT TRIBUTARIES FOR Lake St. Clair - St. Clair Rivers	
JURISDICTION	NAME OF RIVER
Ontario	Thames River Sydenham River
Michigan	Clinton Black (St. Clair Co.) Pine (St. Clair Co.) Belle River

SIGNIFICANT TRIBUTARIES FOR Lake Erie - Detroit River	
JURISDICTION	NAME OF RIVER
Ontario	Grand River Kettle Creek Catfish Creek Big Otter Creek Canard River Lynn River Big Creek
Michigan	Raisin Huron Rouge
Ohio	Portage River Sandusky Huron River Vermillion River Black River Rocky River Cuyahoga River Chagrin River Grand River Ashtabula River Conneaut River Maumee River
New York State	Cattaraugus Creek 18 Mile Creek

Table 1 cont'd

SIGNIFICANT TRIBUTARIES FOR Niagara River	
JURISDICTION	NAME OF RIVER
Ontario	Welland River
New York State	Buffalo River Tonawanda Creek

Table 1 cont'd

SIGNIFICANT TRIBUTARIES FOR Lake Ontario	
JURISDICTION	NAME OF RIVER
Ontario	Trent River Twelve Mile Creek Moira River Welland Canal Salmon River Napanee River Credit River Humber River Don River Duffin Creek Oakville Creek Rouge River Etobicoke River Desjardins Canal Oshawa Creek Highland Creek
New York State	Niagara River 18 Mile Creek ** Genesee River Oswego River Black River

** Monitored by USEPA

Table 1 cont'd

SIGNIFICANT TRIBUTARIES FOR St. Lawrence River	
JURISDICTION	NAME OF RIVER
Ontario	Cataraqui River Gananoque River
New York State	Osegatchie River Grass River Raquette River St. Regis River

LOADING TO THE GREAT LAKES SYSTEM

The loadings shown in the following tables (2 and 3) are from information supplied by the jurisdictions. Because of the variety of methods of measurement and calculation of both concentration and flow involved in these loading figures there is no way to determine the reliability or statistical validity of loadings to the Great Lakes. These tables are to show the information currently available and give a general idea of the overall magnitude of the amount of the materials being discharged to the boundary waters. They should not, however, be regarded as precise measurements nor should they be compared with measurements in previous years because of changes in methodology and frequency of sampling by some jurisdictions.

Municipal Loadings

Municipal loadings are generally the result of measurements of waste concentration and flow made by the municipality itself and submitted to the state or province who in turn summarizes the information and submits it to the IJC.

There has been no documented verification of the precision or accuracy of these measurements nor whether they are conducted in a manner that includes bypasses, overflows, or system failures.

Industrial Loadings

Industrial loadings measurements are made by the industry itself and submitted to the state or province and supplemented by occasional verification surveys by the responsible agency. The information is then summarized and submitted to IJC.

The frequency of these measurements varies from industry to industry, depending upon the requirements of the enforcement agencies.

Like the municipal measurements, precision and accuracy have not been documented.

Tributary Loadings

Tributary loadings are determined in a variety of methods, depending on the agency involved. Generally the agency measures concentrations in the tributaries on a regular schedule from once a year to once every two weeks. These concentrations are then related to flow measurements made by the same or another agency. There is no uniformity of scheduling among the agencies and there is a possibility that the spacing of measurement overlooks major storm flows or spring runoff that could constitute a major part of the annual load.

The connecting channels carry a major part of the load to some of the lakes. Methods of calculating these loads are open to question. The frequency of sampling (usually only in the ice-free period) as well as methods of sampling and analysis are based on systems developed independently by separate agencies and need to be standardized.

Atmospheric Loadings

Atmospheric Loadings are not reported here. This work has been under development with recent special studies for the Upper Lakes Reference Study. Preliminary results from that work indicated significant nutrient loadings for the

Upper Lakes from the atmosphere. On the basis of the work a proposal for monitoring atmospheric loading to a number of materials to the Great Lakes is included in the surveillance program design (see Monitoring of Loadings, L3).

Recommendation

Existing efforts to improve the reliability and compatibility of the loading estimates should be continued and extended by all jurisdictions and agencies.

Table 2

SUMMARY OF
1974 REPORTED BOD LOADING DATA

Basin	Direct Industrial Discharge	Direct Municipal Discharge	Tributary	Total
Lake Superior	145,400 (250,600)	4,500* (6,000)	269,500 (276,300)	419,400 (532,900)
Lake Huron	13,400 (19,100)	4,000 (7,000)	242,100 (178,400)	259,500 (204,500)
Lake Michigan	N (58,700)	54,000 (59,300)	477,000 (325,400)	531,000 (443,400)
Lake Erie	38,800 (61,300)	343,500 (343,900)	177,700 (89,800)	560,000 (495,000)
Lake Ontario**	46,700 (33,200)	79,200 (38,100)	170,700 (118,000)	296,600 (189,300)
Total	244,300 (422,900)	485,200 (454,300)	1,337,000 (987,900)	2,066,500 (1,865,100)

(1973 Reported Data in Parentheses)

All Values Reported in Kilograms/Day.

* Duluth's loading included in tributary loading in 1974 due to relocation of St. Louis River's sampling location.

** 1973 Data from Province of Ontario only.

N Negligible less than 100

Table 2 cont'd

SUMMARY OF

1974 REPORTED SUSPENDED SOLIDS LOADING DATA

Basin	Direct Industrial Discharge	Direct Municipal Discharge	Tributary	Total
Lake Superior	60,732,000 (52,000)	3,000* (7,000)	3,109,000 (1,260,000)	63,844,000 (1,319,000)
Lake Huron	38,000 (31,000)	4,000 (5,000)	3,029,000 (1,364,000)	3,071,000 (1,400,000)
Lake Michigan	25,000 (46,000)	57,000 (1,000)	2,150,000 (1,290,000)	2,232,000 (1,336,000)
Lake Erie	506,000 (1,228,000)	649,000 (667,000)	4,608,000 (2,706,000)	5,763,000 (4,601,000)
Lake Ontario**	95,000 (85,000)	75,000 (45,000)	1,553,000 (1,063,000)	1,723,000 (1,193,000)
Total	61,396,000 (1,442,000)	788,000 (725,000)	14,449,000 (7,683,000)	76,633,000 (9,850,000)

(1973 Reported Data in Parentheses)
All Values Reported in Kilograms/Day.

* Duluth's loading included in tributary loading in 1974 due to relocation of St. Louis River's sampling location.

** 1973 Data from Province of Ontario only.

Table 2 cont'd

SUMMARY OF

1974 REPORTED PHOSPHORUS LOADING DATA

Basin	Direct Industrial Discharge	Direct Municipal Discharge	Tributary	Total
Lake Superior	250	320	5,460	6,030
	(350)	(1,050)**	(3,010)	(4,410)
Lake Huron	N	390	10,050	10,440
	(50)	(440)	(6,440)	(6,930)
Lake Michigan	120	2,990	13,600	16,710
	(40)	(1,220)	(11,230)	(12,490)
Lake Erie	340	19,120	24,560	44,020
	(760)	(28,740)	(13,770)	(43,270)
Lake Ontario*	330	5,360	5,830	11,520
	(600) *	(6,230) *	(3,470) *	(10,300) *
Total	1,040	28,180	59,500	88,720
	(1,800)	(37,680)	(37,920)	(77,400)

(1973 reported data shown in parentheses)

All values reported in kilograms/day

* 1973 data from Province of Ontario only

** Duluth's loading included in Tributary Loading in 1974 due to relocation of St. Louis River's sampling station.

N Negligible less than 10

Table 3

1974 REPORTED BOD LOADING DATA
(All Values Given in Kilograms/Day)

Basin: Lake Superior

Jurisdiction	Direct Industrial Discharge	Direct Municipal Discharge	Tributary	Total
Minnesota	N (700)	600* (1,000)	21,000 (33,800)	21,600 (35,500)
Wisconsin	7,600 (3,600)	1,500 (2,400)	13,700 (6,900)	22,800 (12,900)
Michigan	8,700 (N)	N (100)	16,100 (22,100)	24,800 (22,200)
Ontario	129,100 (246,300)	2,400 (2,500)	218,700 (213,500)	350,200 (462,300)
Total	145,400 (250,600)	4,500 (6,000)	269,500 (276,300)	419,400 (532,900)

(1973 Reported Data Shown in Parentheses)

* Sampling Station on St. Louis River moved to below Duluth in 1974. Duluth's discharge included in tributary loading.

N Negligible less than 100

Table 3 cont'd

1974 REPORTED BOD LOADING DATA

(All Values Given in Kilograms/Day)

Basin: Lake Huron

Jurisdiction	Direct Industrial Discharge	Direct Municipal Discharge	Tributary	Total
Michigan	4,400	1,000	112,800	118,200
	(6,800)	(1,400)	(72,300)	(80,500)
Ontario	9,000	3,000	129,300	141,300
	(12,300)	(5,600)	(106,100)	(124,000)
Total	13,400	4,000	242,100	259,500
	(19,100)	(7,000)	(178,400)	(204,500)

(1973 Reported Data Shown in Parentheses)

1974 REPORTED BOD LOADING DATA

(All Values Given in Kilograms/Day)

Basin: Lake Michigan

Jurisdiction	Direct Industrial Discharge	Direct Municipal Discharge	Tributary	Total
Michigan	N (12,700)	200 (1,400)	223,800 (191,800)	224,000 (205,900)
Wisconsin	ND (43,200)	53,000 (57,900)	232,200 (103,700)	285,200 (204,800)
Illinois	ND (ND)	800 (ND)	ND (ND)	800 (ND)
Indiana	N (2,800)	N (N)	21,000 (29,900)	21,000 (32,700)
Total	N (58,700)	54,000 (59,300)	477,000 (325,400)	531,000 (443,400)

(1973 Reported Data Shown in Parentheses)

ND - No Data

N - Negligible less than 100

1974 REPORTED BOD LOADING DATA

(All Values Given in Kilograms/Day)

Basin: Lake Erie

Jurisdiction	Direct Industrial Discharge	Direct Municipal Discharge	Tributary	Total
Michigan	200 (1,700)	277,300 (295,800)	57,100 (27,500)	334,600 (325,000)
Ohio	900 (1,000)	55,500 (35,400)	72,700 (16,100)	129,100 (52,500)
Pennsylvania	29,100 (21,300)	2,200 (1,300)	N (N)	31,300 (22,600)
New York *	N (ND)	2,300 (ND)	ND (400)	2,300 (400)
Ontario	8,600 (37,300)	6,200 (11,400)	47,900 (45,800)	62,700 (94,500)
Total	38,800 (61,300)	343,000 (343,900)	177,700 (89,800)	560,000 (495,000)

(1973 Reported Data Shown in Parentheses)

* Incomplete Data as of March 24, 1975. Loading data from New York were estimated by the state on the basis of 1 mg/l in the effluent. This basis does not appear to be valid.

ND No Data

N Negligible less than 100

1974 REPORTED BOD LOADING DATA
(All Values Given in Kilograms/Day)

Basin: Lake Ontario

Jurisdiction	Direct Industrial Discharge	Direct Municipal Discharge	Tributary	Total
New York*	29,800 (ND)	35,500 (ND)	69,300 (ND)	134,600 (ND)
Ontario	16,900 (33,200)	43,700 (38,100)	101,400 (118,000)	162,000 (189,300)
Total	46,700 (33,200)	79,200 (38,100)	170,700 (118,000)	296,600 (189,300)

(1973 Reported Data Shown in Parentheses)

* Incomplete data. Loading data from New York were estimated by the state on the basis of 1 mg/l in the effluent. This basis does not appear to be valid.

ND No Data

Table 3 cont'd

1974 REPORTED SUSPENDED SOLIDS LOADING DATA
(All Values Given in Kilograms/Day)

Basin: Lake Erie

Jurisdiction	Direct Industrial Discharge	Direct Municipal Discharge	Tributary	Total
Michigan	180,000 (489,000)	555,000 (626,000)	759,000 (186,000)	1,494,000 (1,301,000)
Ohio	265,000 (706,000)	79,000 (30,000)	2,865,000 (1,217,000)	3,209,000 (1,953,000)
Pennsylvania	20,000 (N)	7,000 (N)	N (N)	27,000 (N)
New York *	14,000 (ND)	2,000 (ND)	ND (ND)	16,000 (ND)
Ontario	27,000 (33,000)	6,000 (11,000)	984,000 (1,303,000)	1,017,000 (1,347,000)
Total	506,000 (1,228,000)	649,000 (667,000)	4,608,000 (2,706,000)	5,763,000 (4,601,000)

(1973 Reported Data Shown in Parentheses)

* Incomplete data as of March 24, 1975. Loading data from New York were estimated by the state on the basis of 1 mg/l in the effluent. This basis does not appear to be valid.

ND No Data

N Negligible less than 1000

1974 REPORTED SUSPENDED SOLIDS LOADING DATA
(All Values Given in Kilograms/Day)

Basin: Lake Superior

Jurisdiction	Direct Industrial Discharge	Direct Municipal Discharge	Tributary	Total
Minnesota	6.07X10^{7} (N)**	N* (5,000)	60,000 (65,000)	60,760,000 (70,000)
Wisconsin	1,000 (1,000)	1,000 (N)	1,521,000 (91,000)	1,523,000 (92,000)
Michigan	N (3,000)	N (N)	346,000 (697,000)	346,000 (700,000)
Ontario	31,000 (48,000)	2,000 (2,000)	1,182,000 (407,000)	1,215,000 (457,000)
Total	60,732,000 (52,000)	3,000 (7,000)	3,109,000 (1,260,000)	63,844,000 (1,319,000)

(1973 Reported Data Shown in Parentheses)

* Sampling Station on St. Louis River moved to below Duluth in 1974. Duluth's discharge included in tributary loading.

** Reserve Mining ~~not~~ ~~in~~cluded last year.

N Negligible less than 1000

Table 3 cont'd

1974 REPORTED SUSPENDED SOLIDS LOADING DATA
(All Values Given in Kilograms/Day)

Basin: Lake Huron

Jurisdiction	Direct Industrial Discharge	Direct Municipal Discharge	Tributary	Total
Michigan	21,000 (7,000)	1,000 (N)	1,919,000 (377,000)	1,941,000 (384,000)
Ontario	17,000 (24,000)	3,000 (5,000)	1,110,000 (987,000)	1,130,000 (1,016,000)
Total	38,000 (31,000)	4,000 (5,000)	3,029,000 (1,364,000)	3,071,000 (1,400,000)

(1973 Reported Data Shown in Parentheses)

N Negligible less than 1000

1974 REPORTED SUSPENDED SOLIDS LOADING DATA
(All Values Given in Kilograms/Day)

Basin: Lake Michigan

Jurisdiction	Direct Industrial Discharge	Direct Municipal Discharge	Tributary	Total
Michigan	14,000 (21,000)	N (1,000)	1,125,000 (810,000)	1,139,000 (832,000)
Wisconsin	11,000 (ND)	56,000 (N)	912,000 (371,000)	979,000 (371,000)
Illinois	ND (ND)	1,000 (ND)	ND (ND)	1,000 (ND)
Indiana	N (25,000)	N (N)	113,000 (109,000)	113,000 (134,000)
Total	25,000 (46,000)	57,000 (1,000)	2,150,000 (1,290,000)	2,232,000 (1,336,000)

(1973 Reported Data Shown in Parentheses)

ND - No Data

N - Negligible less than 1000

1974 REPORTED SUSPENDED SOLIDS LOADING DATA

(All Values Given in Kilograms/Day)

Basin: Lake Ontario

Jurisdiction	Direct Industrial Discharge	Direct Municipal Discharge	Tributary	Total
New York *	37,000 (ND)	35,000 (ND)	617,000 (ND)	689,000 (ND)
Ontario	58,000 (85,000)	40,000 (45,000)	936,000 (1,063,000)	1,034,000 (1,193,000)
Total	95,000 (85,000)	75,000 (45,000)	1,553,000 (1,063,000)	1,723,000 (1,193,000)

(1973 Reported Data Shown in Parentheses)

* Incomplete Data. Loading data from New York were estimated by the state on the basis of 1 mg/l in the effluent. This basis does not appear to be valid.

ND No Data

1974 REPORTED PHOSPHORUS LOADING DATA
(All values given in kilograms/day)

Basin: Lake Superior

Jurisdiction	Direct Industrial Discharge	Direct Municipal Discharge	Tributary	Total
Minnesota	N (N)	50 * (720)	660 (610)	710 (1,330)
Wisconsin	N (N)	160 (190)	1,800 (360)	1,960 (550)
Michigan	N (N)	N (N)	450 (1,090)	450 (1,090)
Ontario	250 (350)	110 (140)	2,550 (950)	2,910 (1,430)
Total	250 (350)	320 (1,050)	5,460 (3,010)	6,030 (4,410)

(1973 reported data shown in parentheses)

* Sampling Station on St. Louis River moved to below Duluth in 1974. Duluth's discharge included in Tributary Loading.

N Negligible less than 10

1974 PHOSPHORUS LOADING DATA
(All values given in kilograms/day)

Basin: Lake Michigan

Jurisdiction	Direct Industrial Discharge	Direct Municipal Discharge	Tributary	Total
Michigan	N (40)	40 (0)	7,300 (5,770)	7,340 (5,800)
Wisconsin	120 (N)	2,870 (1,220)	5,500 (4,100)	8,500 (5,320)
Illinois	ND (ND)	80 (ND)	ND (ND)	80 (ND)
Indiana	N (N)	N (N)	800 (1,360)	800 (1,360)
Total	120 (40)	2,990 (1,220)	13,600 (11,230)	16,710 (12,490)

(1973 data shown in parentheses)

ND - No Data

N - Negligible less than 10

1974 PHOSPHORUS LOADING DATA
(All values given in kilograms/day)

Basin: Lake Huron

Jurisdiction	Direct Industrial Discharge	Direct Municipal Discharge	Tributary	Total
Michigan	N (N)	80 (40)	6,650 (3,640)	6,730 (3,680)
Ontario	N (50)	310 (400)	3,400 (2,800)	3,710 (3,250)
Total	N (50)	390 (440)	10,050 (6,440)	10,440 (6,930)

(1973 reported data shown in parentheses)

N Negligible less than 10

1974 PHOSPHORUS LOADING DATA

(All values given in kilograms/day)

Basin: Lake Erie

Jurisdiction	Direct Industrial Discharge	Direct Municipal Discharge	Tributary	Total
Michigan	160 (140)	15,220 (24,460)	4,110 (1,510)	19,490 (26,110)
Ohio	N (N)	3,220 (3,060)	15,760 (7,140)	18,980 (10,200)
Pennsylvania	N (240)	380 (530)	N (N)	380 (770)
New York *	N	90 (110)	ND (350)	90 (460)
Ontario	180 (380)	210 (580)	4,690 (4,770)	5,080 (5,730)
Total	340 (760)	19,120 (28,740)	24,560 (13,770)	44,020 (43,270)

(1973 data shown in parentheses)

* incomplete data as of March 24, 1975

ND No Data

N negligible less than 10

1974 PHOSPHORUS LOADING DATA

(All Values in Kilograms/day)

Basin: Lake Ontario

Jurisdiction	Direct Industrial Discharge	Direct Municipal Discharge	Tributary	Total
New York *	160 (ND)	1,300 (ND)	2,750 (ND)	4,210 (ND)
Ontario	170 (600)	4,060 (6,230)	3,080 (3,470)	7,310 (10,300)
Total	330 (600)	5,360 (6,230)	5,830 (3,470)	11,520 (10,300)

(1973 data shown in parentheses)

* Incomplete data

DETAILED ASSESSMENT OF WATER QUALITY

— LAKE ERIE/LAKE ST. CLAIR SYSTEM

INTRODUCTION

The four items of the Terms of Reference of the Surveillance Subcommittee embody two basic objectives - the design of a Surveillance Program for the Great Lakes, and the interpretation of the data generated in these programs. The former objective has preeminence in the terms of reference while the latter is frequently the subject of requests to the Subcommittee regarding knowledge about the present state of the lakes.

It was apparent from the first efforts of the Subcommittee that the data which was already available from a large number of agencies could be examined in greater depth to aid in answering both the question of how best to carry out surveillance and the question of how the lakes were changing. This was the subject of the first committee activity in 1974, the first year of its operation, while basic data on existing surveillance programs were being compiled.

Attention was centred upon the Lake Erie and St. Clair - Detroit River Systems, and each agency developed detailed reports on the data collected since the Lower Lakes Reference

Report of 1969. Lake Erie was chosen since it is considered to have the most critical problems and the Detroit River System constitutes the most important single influence on Lake Erie.

Subsequently the agencies undertook to summarize one or more aspects of the water quality situation from the agency reports. These summary reports appear in this section of the Appendix. The detailed reports are available in the files of the IJC Regional Office. They are too voluminous to appear here. There are also many references to the open literature.

The results of this analysis have provided both an assessment of water quality conditions and the basis for the preliminary design of a Great Lakes Surveillance Program.

A summary of findings along with parameter summaries for the Lake Erie and St. Clair-Detroit River System followed by the detailed water quality assessment for Lake Erie, the Detroit River, Lake St. Clair and the St. Clair River is contained in this section. The Surveillance Program design is contained in a later section.

SUMMARY OF FINDINGS

General Water Quality Conditions

St. Clair River. The present water quality is generally not restrictive to any use, including recreation, water supply and the support of aquatic life, with the exception of bottom fauna in some locations.

Lake St. Clair. The commercial fishery is still closed for specific species, but reductions in the mercury contamination have been noted.

Detroit River. There is improvement in water quality conditions with general enhancement of aesthetic features. Restocking of sport fish has been undertaken.

Lake Erie. Lake Erie appears, on the whole, to be no longer deteriorating, having stabilized at a still undesirable condition, but evidencing improvement in contact recreational aspects. There remains serious concern for the low dissolved oxygen conditions in the central basin, but some particular improvements have taken place in the reduction of taste and odour problems at water supply intakes and in bacterial contamination on beaches.

Problems

St. Clair River. Fish tainting still remains a problem as do periodic localized bacterial levels above IJC objectives. Occassional oil spills continue and industrial waste discharge has had a marked effect on the benthic community in the river.

Lake St. Clair. Mercury is still present in the fish population above acceptable levels.

Detroit River. Total iron as well as total and fecal coliforms are present in localized areas at levels exceeding the IJC objectives. Accidental industrial spills still occur.

Lake Erie . There are dissolved oxygen conditions present in summer in all three Lake Erie basins at levels below the IJC objective. Primary biological production is still too high to meet the general objectives laid out in the Water Quality Agreement. While the number of beach closings is decreasing, some closings are still in effect due to bacteriological contamination. There is still sufficient mercury in some fish to justify some restrictions of commercial fishing. There is concern about changing species composition reflecting poorer water quality and about the introduction of exotic species thought to be largely from the discharge of ballast waste.

Response to Abatement Programs Since the Late 1960's

St. Clair River. Decreases in chloride levels along the Canadian shore are directly attributable to reduced industrial inputs. Decreases in phosphorus concentrations have been noted downstream of municipal sources in response to the initiation of phosphorus removal.

Lake St. Clair. Mercury levels have decreased in both fish and sediment due to the elimination of mercury sources and the natural redistribution of mercury in the sediments.

Detroit River. Decreases in phosphorus concentrations have been noted due to improvements in sewage treatment plants, improvements in sewage collection systems and detergent reformulations. Reductions in iron concentrations are related to abatement measures.

Lake Erie. Improved bacterial conditions nearshore are related to improved sewage treatment practice. Small decreases in both the concentration and quantity of phosphorus in the west basin of Lake Erie is thought to be, in part, due to phosphorus abatement programs.

The volume of Lake Erie is equivalent to about three year's inflow (Detroit River plus other tributaries). With a thoroughly mixed lake, an abrupt change in the loading to the lake of a conservative substance will be about 50% effective in 3 years and 90% effective in changing lake conditions in 7 to 8 years. The fact that reduction in loadings of phosphorus are taking place gradually and the fact that regeneration of phosphorus from bottom sediments takes place, will probably give rise to a somewhat even slower response for Lake Erie.

PARAMETER SUMMARIES

Chloride, Total Dissolved Solids, Conductivity

Chlorides, TDS and conductivity are a group of measurements which are indicative of general water quality conditions. Chloride is a very specific item, which, since it is quite conservative, can be traced through the system without concern for its loss or chemical interactions. Chloride data, because it is free of complications caused by chemical interactions, usually provides dilution effects that can be applied as a reference for other parameters which are affected by interactions and loss within the system.

Chloride concentrations in Lake Erie have decreased. Additional loading to the St. Clair-Detroit River system has been essentially constant during the years 1964-1974, and therefore any variation in mean annual chloride concentration at the river mouth is attributable only to variations in mean annual flow. Direct chloride loading has been essentially invariant since 1964 and equal to about 1.5 MT/year. This implies changes are attributable to changes in flow through the system and essentially vary inversely with flow if these loadings remain constant. If point source loading to Lake Erie remain constant, mean lake concentrations can vary from 30.5 to 22 mg/l for flows ranging from 4500 to 7000 m^3/sec. (which is the range of normal flowthrough).

Conductivity and dissolved solids are closely related to each other. An objective of 200 mg/l has been set as an IJC objective for total dissolved solids, but conductivity data are more useful because of the ease in the precision of measuring. Appropriate conversion factors can be applied to conductivity data to provide a TDS figure.

Some uncertainity remains about the factor to be used for Lake Erie waters in converting conductivity data to TDS. A best estimate for a factor when dealing with lake averages is 0.62. Based on this factor the general level of TDS is now below the IJC objective. Nearshore values do approach and, in some cases, exceed the objective. A drop of conductivity and TDS has been noted since the late 1960's to where basin averages are now all below 200 mg/l. This drop is comparable with the drop in chloride levels and is therefore probably due to increased flowthrough in the system - a dilution effect. Return to normal or below normal flows will result in increased TDS and conductivity if TDS loading is held constant.

Total dissolved solids levels do not violate the 200 mg/l objective in the St. Clair River - Detroit River System.

Nutrients

The key nutrient subject to remedial measures is phosphorus. Tracing it through the system, it is found that phosphorus transport out of the St. Clair River system has not significantly changed in spite of increased flow. However, there are reported reductions in phosphorus loading to the system below the St. Clair River. This is reflected in part in reported reduced loading through the Detroit River to Lake Erie.

Since the Detroit River is the principal source of phosphorus for Lake Erie, changes should be evident first in the western basin. Since phosphorus interacts substantially with biota and bottom sediments it is not easily subject to a closed material balance calculation for the Lake. Nonetheless trends should be reflected in near source areas.

Some reduction in total phosphorus concentrations for surface water and total phosphorus content has been reported for the western basin. Central basin data apparently show no reduction in P concentrations, with no change evident in total P content. No change is evident in the eastern basin. Phosphorus levels reported show wide seasonal variations which tends to obscure trends.

Total inorganic nitrogen in the open lake shows no significant change, although there have been increases in local areas such as the mouth of the Grand River, and in the Detroit River. Highest values occur in spring in the west basin.

Dissolved Oxygen

One of the major concerns about Lake Erie is the depletion of dissolved oxygen in the hypolimnion of the lake during the period of summer stratification. The extent and rate of this oxygen depletion have been the subject of considerable study.

The extent of oxygen depletion in the hypolimnion in the central basin in the past 2 years has reached close to the maximum possible; i.e. anoxic conditions in virtually the whole hypolimnion by the end of summer. Oxygen depletion rates have held steady (within $\pm$ 15%) for the past 5 years. Sufficiently precise measurements are available only for recent years making detailed comparisons with earlier years more difficult, however, an approximate doubling between 1930 and the mid 1960's and realization of essentially stable conditions since that time is evident. Eastern basin summer hypolimnion values close to the bottom are below the IJC objective. Under conditions of temporary stratification (warm, calm weather) in the summer, serious oxygen depletion still takes place in the Western basin.

The flushing time lag has already been referred to in the section on chlorides indicating that the lake volume is equivalent to 3 years flow of the Detroit River and tributaries, and hence the full effect of an abrupt change in loading would not be reflected in the lake for a period of seven to eight years. A further lag in the response is engendered by the fact that nutrients are regenerated from sediments in anoxic conditions and in conditions where the lake bottom is stirred by storm activity.

Biology

There have been several changes in the biology in Lake Erie since 1967 which represent trends. In the open lake, production coupled with external loading of organic matter remains high enough to cause serious oxygen depletion in the bottom waters of the western and central parts of the lake, and to cause decreasing levels of oxygen in the deeper eastern basin as well.

On the other hand, phytoplankton biomass estimates from selected water intakes along the Ohio and Ontario shorelines generally show lower values than mid-lake, and a decreasing trend from 1967. It seems likely that at least some of this lesser impact may be related, as has been the case for that of the attached alga Cladophora, in some way to the high water levels of the past few years. It is also possible that the lower rates nearshore are the first response to the phosphorus reduction programs.

One serious aspect of the sustained oxygen deficit in bottom waters is the apparent deterioration of benthic communities as evidenced by the increase in numbers and spread of distribution of "pollution tolerant" oligochaetes and the decrease in the numbers of amphipods. There is also a decrease in the mayfly nymph (normally restricted to cold, well aerated waters). This decrease has continued in the western central basins and has now spread to the eastern basin.

Another problem is the introduction of potentially deleterious non-native species and the presence of pollution - tolerant organisms into the Lake Erie community. While many of the forms introduced may not survive, the effects of those which do, such as the alewife, may be considerable on the aquatic community, and may result in as yet unpredictable impacts on the use of the Lake.

Bacteriology

Violation of the objectives occurs periodically in the St. Clair and frequently in the Detroit Rivers. Occasional violations are noted in the open waters of the western basin of Lake Erie, and few are reported in the open waters of the central and eastern basins of the Lake.

In the central and eastern basins violations occur near specific sources.

Beach sampling data from Ohio and Pennsylvania suggest a trend of improvement which is directly attributed to pollution abatement in the vicinity of the beaches.

pH

The pH range specified in IJC objectives, 6.7 to 8.5, is exceeded frequently. On the high end of the scale it is usually associated with high algal growth situations, and where levels are lower than 6.7, industrial sources are implicated.

Toxic Materials

At present the availability of information for toxic materials appears to be rather limited; however no adverse reports in the quality of the water per se have been noted as opposed to sediment and biota.

Reports on harbor dredging activities and information from sediment sampling surveys in the western basin of Lake Erie indicate elevated levels of several heavy metals. These levels have not been associated with any deterioration of water quality.

Volatile organics and radioactivity levels do not appear to be any cause for concern at the moment. Pesticides generally are undetectable in the open waters of Lake Erie, however, studies regarding reproduction failures characterized by poor hatchability of Herring Gull eggs indicate contamination does exist.

LAKE ERIE

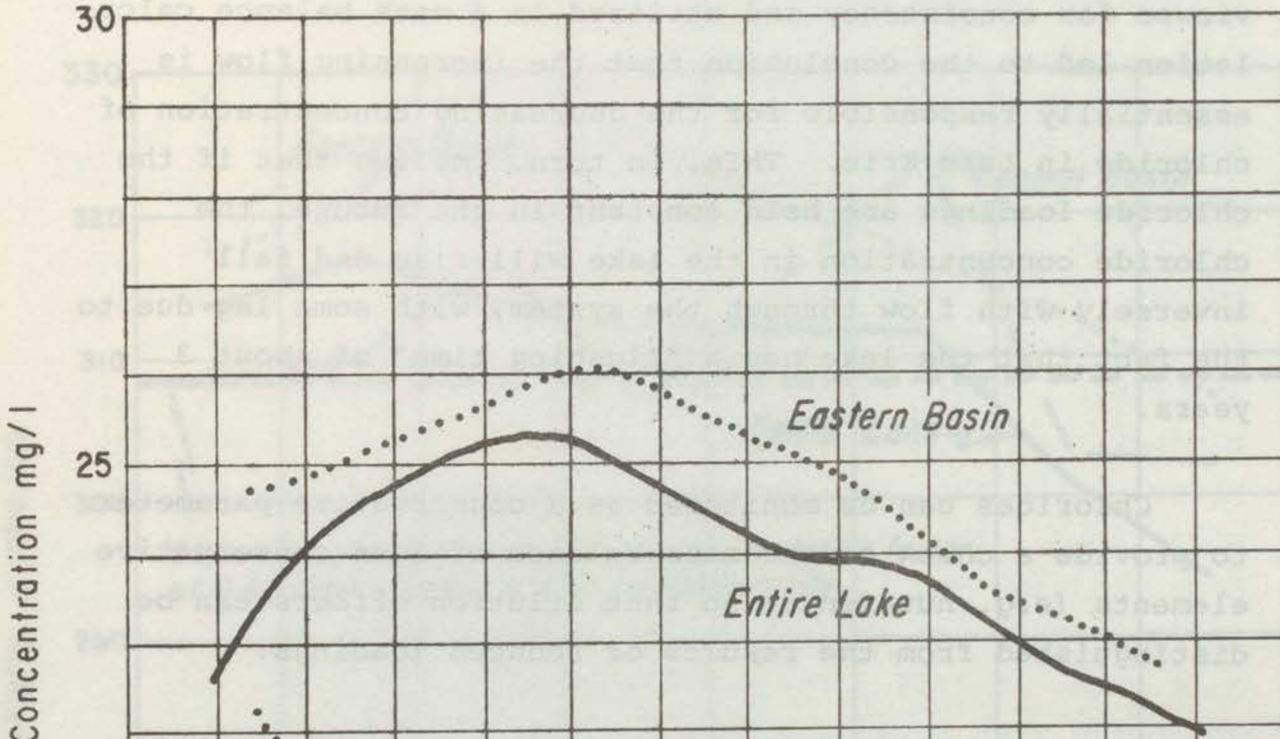
Chloride

Chlorides are a general indicator of water quality. Sources in Lake Erie include upstream Lake Huron, industry, deicing salts, municipal STP's and the soils in tributary basins. In the late 1960's it was estimated that about 65% of the chloride came from industry and deicing.

The data presented by Beeton (1965) and cited in the IJC Report on Pollution in the Lower Lakes (1969) showed lower chloride concentrations in the years prior to 1965. Since that time, data from several agencies (see detailed reports in IJC files and Detroit and St. Clair River reports in this document) have shown a slight rise and then a substantial reduction in the chloride concentrations in Lake Erie (Figure 2).

Chloride in lake water is conservative, not being subject to decay, biological degradation or sedimentation. Therefore a mass balance calculation is relatively straightforward. That is, the sum of the inputs minus the amounts discharged must equal the amount of change of material in the lake (either through change in lake volume, change in lake concentrations, or both).

Flowthrough is a major factor in this calculation. The decade under consideration here, 1965-1974, was characterized by increasing flowthrough from 4437 m^3/sec in 1964 which is second only to the 1934 low flow of 4255 m^3/sec in 75 years of record, to a high of 6734 m^3/sec in 1973.



LAKE ERIE CHLORIDE CONCENTRATIONS

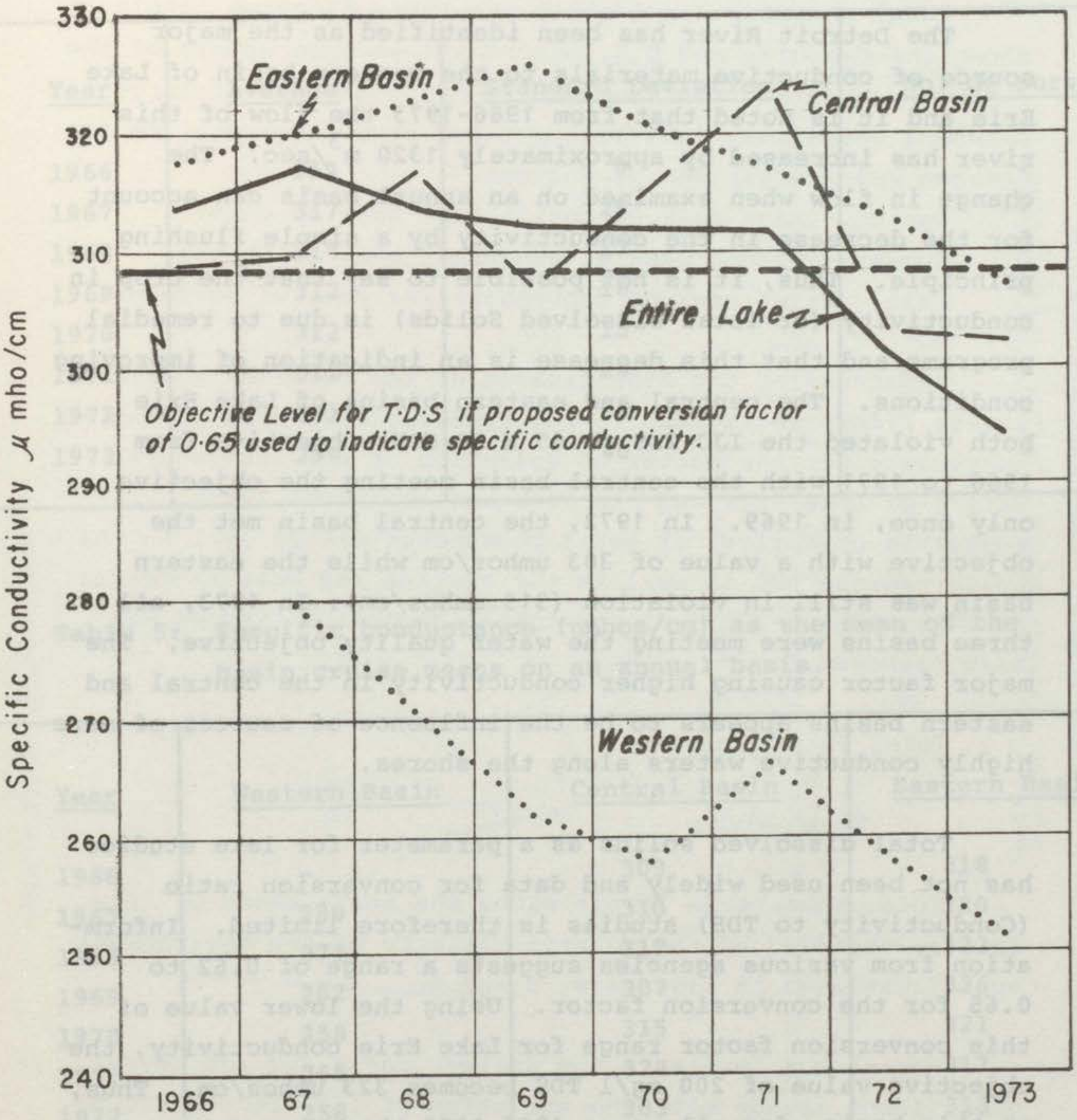
FIGURE 2

An analysis of the chloride data available when reviewed for consistency and utilized in a mass balance calculation led to the conclusion that the increasing flow is essentially responsible for the decreasing concentration of chloride in Lake Erie. This, in turn, implies that if the chloride loadings are held constant in the future, the chloride concentration in the lake will rise and fall inversely with flow through the system, with some lag due to the fact that the lake has a "flushing time" of about 3 years.

Chlorides can be monitored as a conservative parameter to provide a check on the mass balance of less conservative elements (e.g. nutrients) so that dilution effects can be distinguished from the results of reduced loadings.

Open Waters Specific Conductivity (Total Dissolved Solids)

From 1966 to 1971 the conductivity of the open waters of Lake Erie did not change appreciably from the value of 313 umhos/cm. This trend ended abruptly in 1972 with a drop to 301 umhos/cm. This decline continued in 1973 to bring the conductance down to 294 umhos/cm (see Table 4). If a standard conversion factor of 0.65 for the equivalence of conductivity and total dissolved solids is employed, the objective for conductivity in the Great Lakes waters would be 308 umhos/cm (See Appendix A, page 209). This would indicate that Lake Erie on the average, was in violation of the objective until 1971 and that it is now in compliance (see Figure 3). Examination of the data by basins shows clearly the distinction of the western basin from the rest of the lake. The conductivity of the western basin shows a steady decline from 1967 to 1973 whereas the central and eastern basins fluctuated and show only a relatively small



SPECIFIC CONDUCTIVITY IN LAKE ERIE

FIGURE 3

decline in 1972 and 1973 interrupted in 1971 by a slight increase from the trend line. (see Table 5 and Figure 3).

The Detroit River has been identified as the major source of conductive materials to the western basin of Lake Erie and it is noted that from 1966-1973 the flow of this river has increased by approximately 1320 m^3/sec. The change in flow when examined on an annual basis can account for the decrease in the conductivity by a simple flushing principle. Thus, it is not possible to say that the drop in conductivity (or Total Dissolved Solids) is due to remedial programs and that this decrease is an indication of improving conditions. The central and eastern basins of Lake Erie both violated the IJC TDS (0.65 X SP CON) objective from 1966 to 1971 with the central basin meeting the objective only once, in 1969. In 1972, the central basin met the objective with a value of 303 umhos/cm while the eastern basin was still in violation (313 umhos/cm). In 1973, all three basins were meeting the water quality objective. The major factor causing higher conductivity in the central and eastern basins appears to be the influence of sources of more highly conductive waters along the shores.

Total dissolved solids as a parameter for lake studies has not been used widely and data for conversion ratio (Conductivity to TDS) studies is therefore limited. Information from various agencies suggests a range of 0.62 to 0.65 for the conversion factor. Using the lower value of this conversion factor range for Lake Erie conductivity, the objective value of 200 mg/l TDS becomes 323 umhos/cm. Thus, on this basis, for all years 1966-1973 there are values very close to the objective, particularly in the eastern basin.

Table 4: Specific conductance (umhos/cm) as the mean of the whole lake cruise means on an annual basis.

Year	Average	Standard Deviation	No. of Surveys
1966	314	9	1
1967	317	29	10
1968	314	17	5
1969	312	18	8
1970	312	18	9
1971	312	24	6
1972	301	20	6
1973	294	40	5

Table 5: Specific conductance (umhos/cm) as the mean of the basin cruise means on an annual basis.

Year	Western Basin	Central Basin	Eastern Basin
1966	-	309	318
1967	280	310	320
1968	271	317	323
1969	262	307	326
1970	258	315	321
1971	266	324	317
1972	258	303	313
1973	251	302	307

Nutrient Chemistry

Total phosphorus and total inorganic nitrogen levels along the Canadian and U.S. shores and in open waters of the lake were examined for possible trends. Because of large seasonal variation, data were grouped into three periods for between year comparison as follows:

Spring - Last week of April-first week of June;
Summer - Second week of June-last week of August;
Fall - First week of September-last week of November.

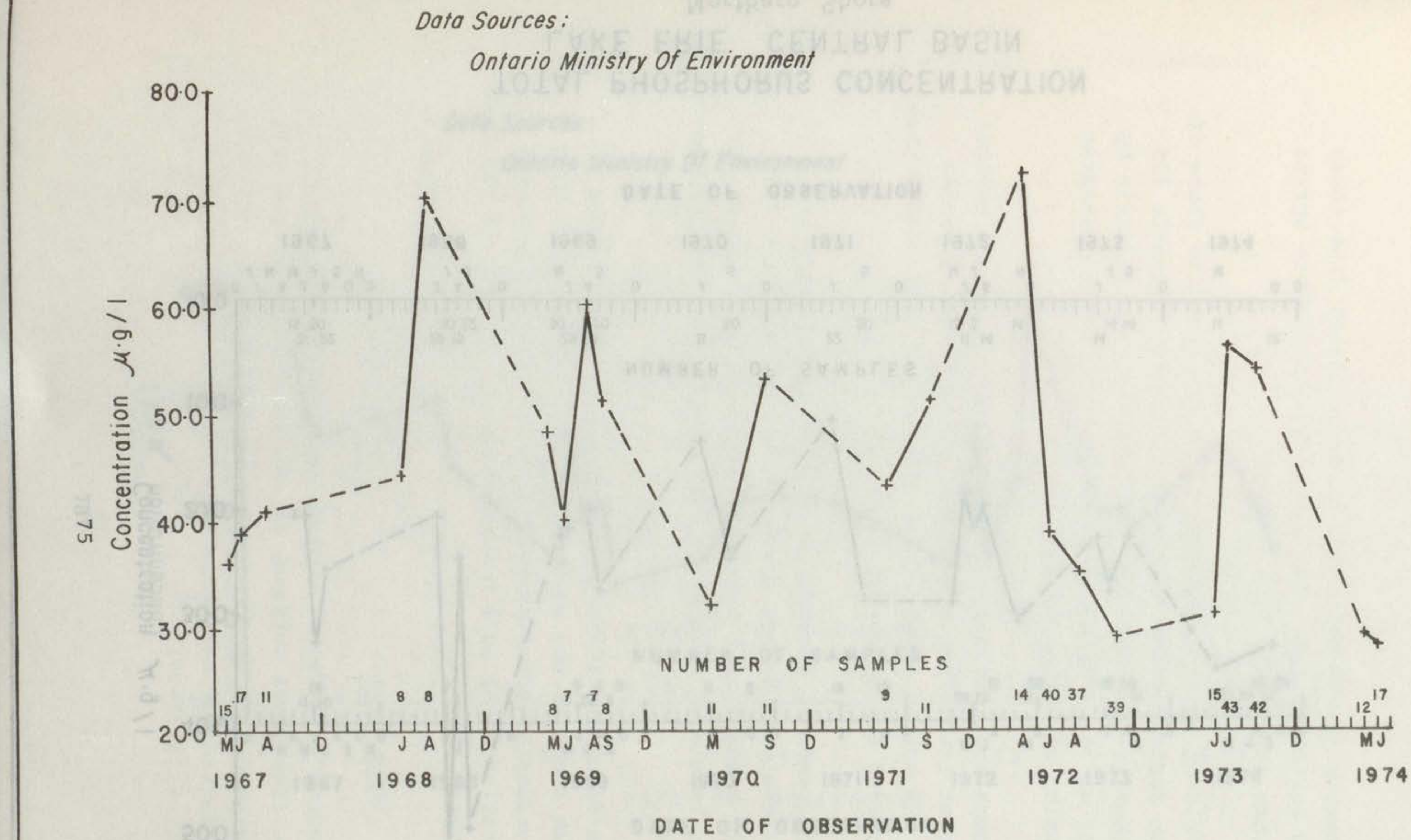
In assessing the significance of the observed nutrient levels reference is made to the criteria developed at the Conference for the Matter of Pollution of the Interstate Waters of Lake Erie and its Tributaries (FWPCA 1967). The suggested objective for total phosphorus was 25 μg/l in the western basin and 15 μg/l in the central and eastern basins. An objective of 300 μg/l for total inorganic nitrogen was also proposed.

Total Phosphorus

North Shore

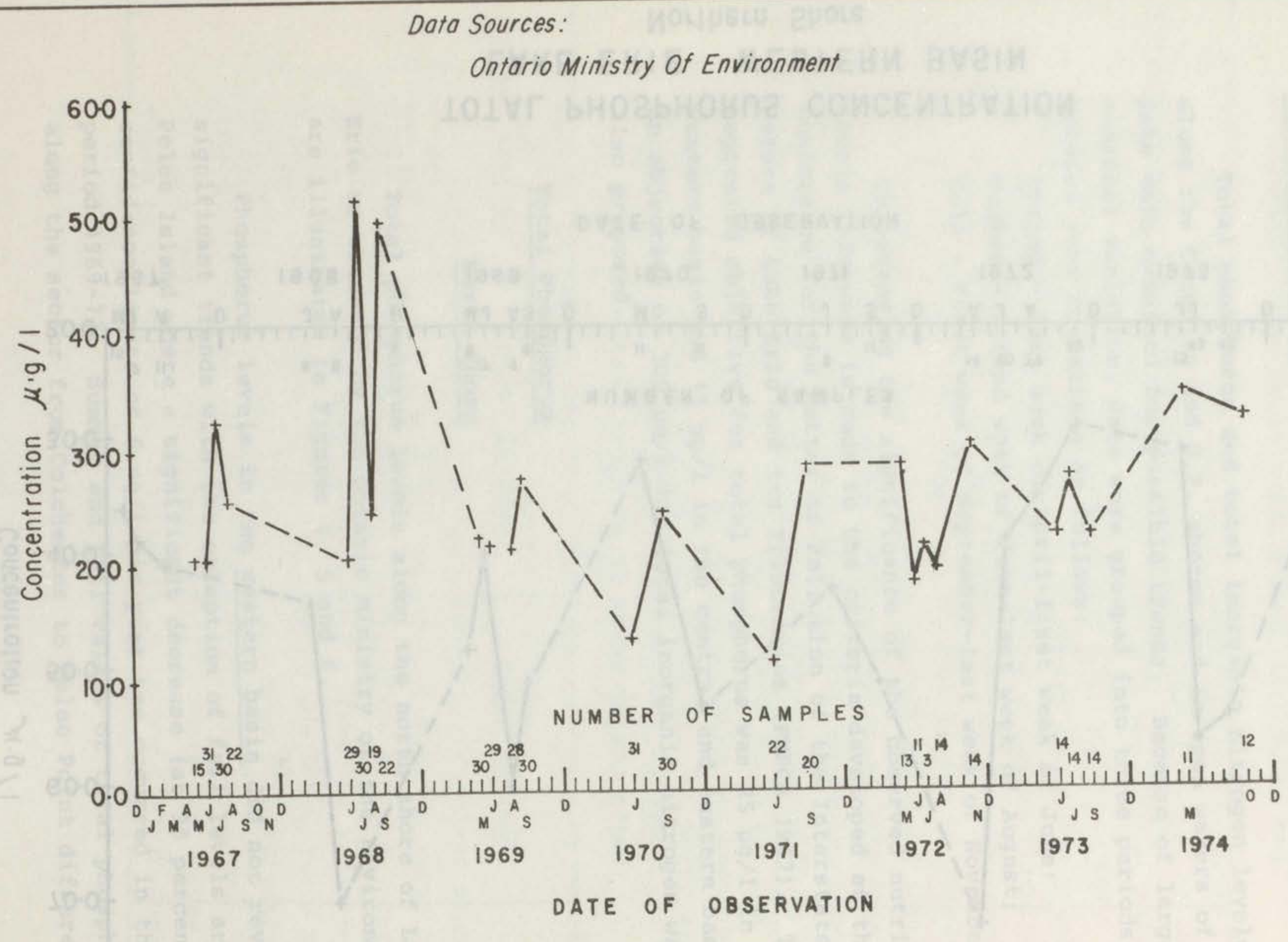
Total phosphorus levels along the north shore of Lake Erie as observed by the Ontario Ministry of the Environment are illustrated in Figures 4, 5 and 6.

Phosphorus levels in the western basin did not reveal significant trends with the exception of fall levels around Pelee Island where a significant decrease (at 95 percent confidence limit) of 6 μg/l per year has occurred in the period 1969-73. Summer and fall values of total phosphorus along the sector from Colchester to Pelee Point differed



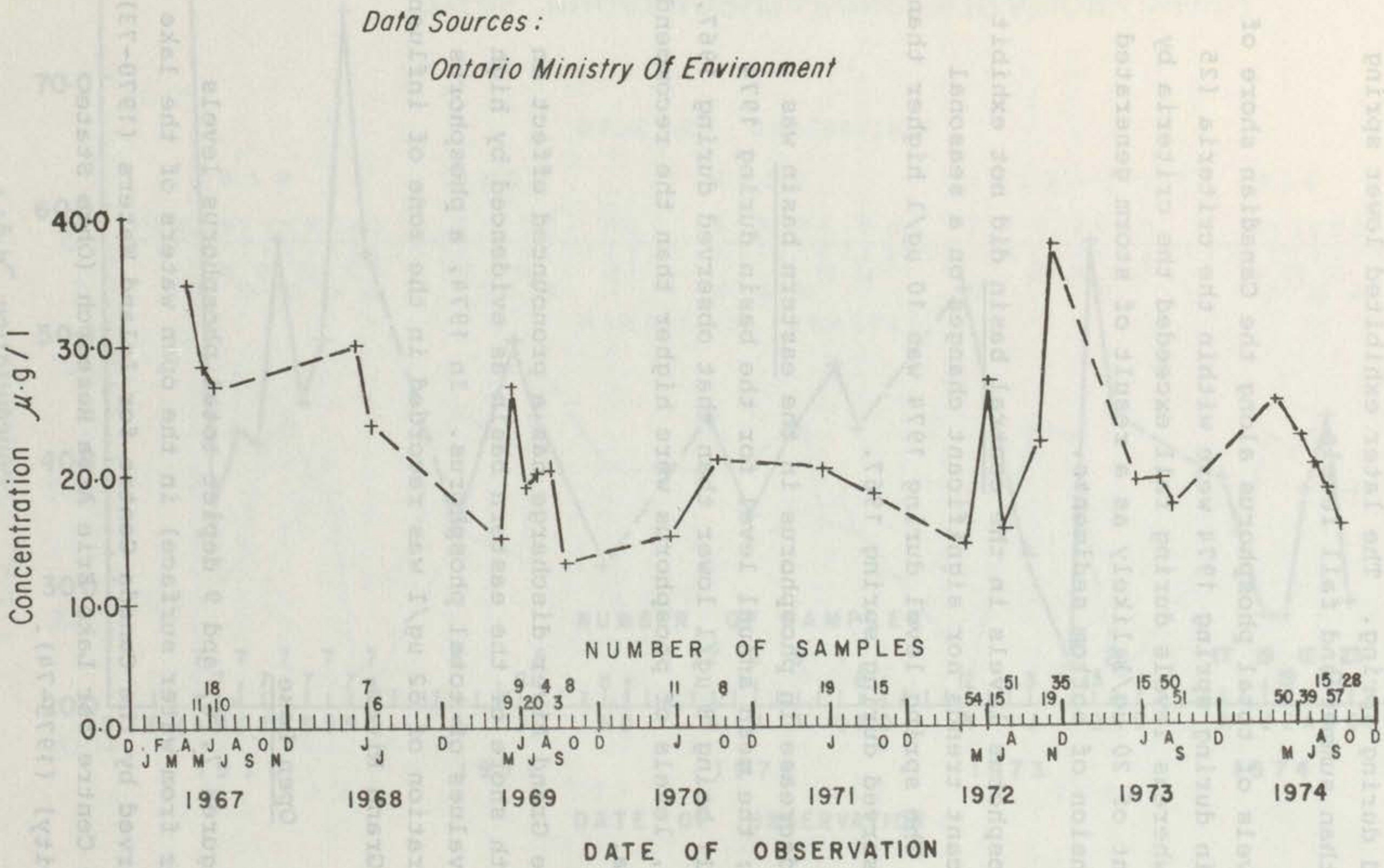
TOTAL PHOSPHORUS CONCENTRATION
LAKE ERIE WESTERN BASIN
Northern Shore

FIGURE 4



TOTAL PHOSPHORUS CONCENTRATION
LAKE ERIE CENTRAL BASIN
Northern Shore

FIGURE 5



TOTAL PHOSPHORUS CONCENTRATION
LAKE ERIE EASTERN BASIN
Northern Shore

FIGURE 6

significantly (at 99 percent confidence level) from those observed during spring. The later exhibited lower spring values than summer and fall levels.

Levels of total phosphorus along the Canadian shore of the basin during spring 1974 were within the criteria (25 µg/l), whereas levels during fall exceeded the criteria by an amount of 20 µg/l likely as a result of storm generated resuspension of bottom sediments.

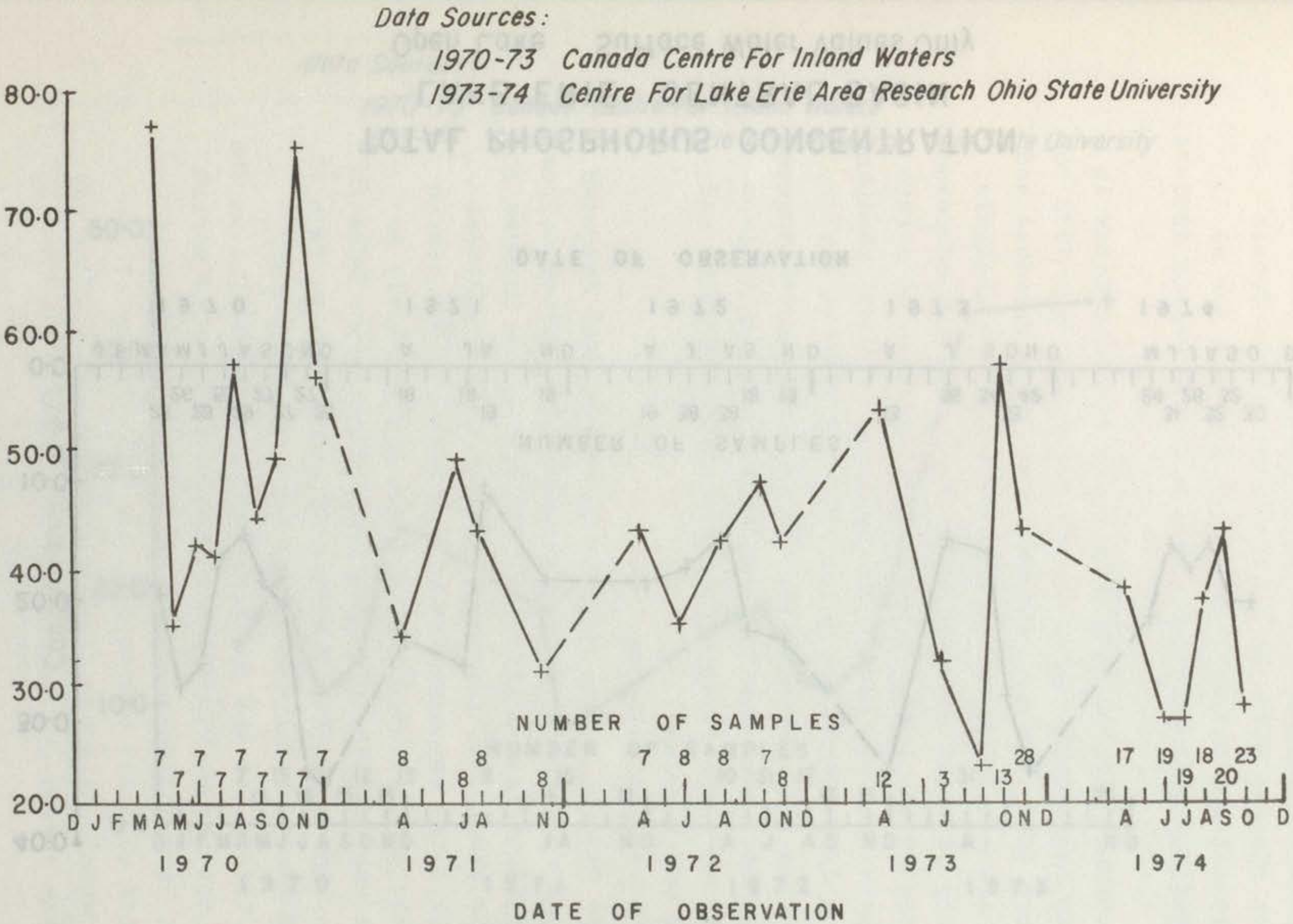
Phosphorus levels in the <u>central basin</u> did not exhibit significant trends nor significant changes on a seasonal basis. The spring level during 1974 was 10 µg/l higher than that observed during spring 1967.

A decrease in phosphorus in the <u>eastern basin</u> was noticed; the mean annual level for the basin during 1974 (24 µg/l) being 8 µg/l lower than that observed during 1967. However, levels of phosphorus were higher than the recommended criteria.

The Grand River discharge has a pronounced effect on the north shore of the eastern basin as evidenced by high spring values of total phosphorus. In 1974, a phosphorus concentration of 52 µg/l was recorded in the zone of influence of the Grand River.

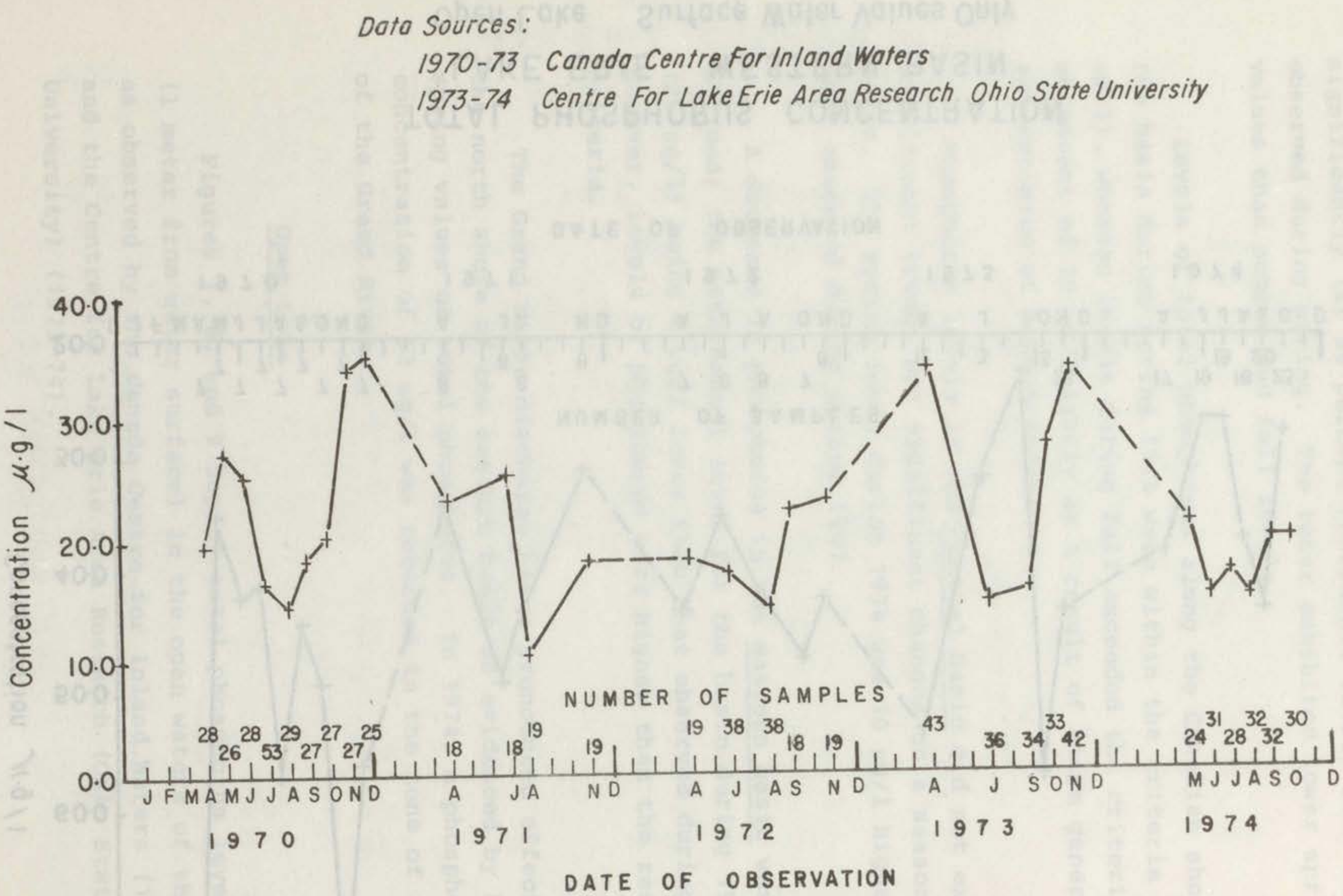
<u>Open Lake</u>

Figures 7, 8, and 9 depict total phosphorus levels (1 meter from water surface) in the open waters of the lake as observed by the Canada Centre for Inland Waters (1970-73) and the Centre for Lake Erie Area Research (Ohio State University) (1973-74).



TOTAL PHOSPHORUS CONCENTRATION
LAKE ERIE WESTERN BASIN
Open Lake Surface Water Values Only

FIGURE 7



TOTAL PHOSPHORUS CONCENTRATION

LAKE ERIE CENTRAL BASIN

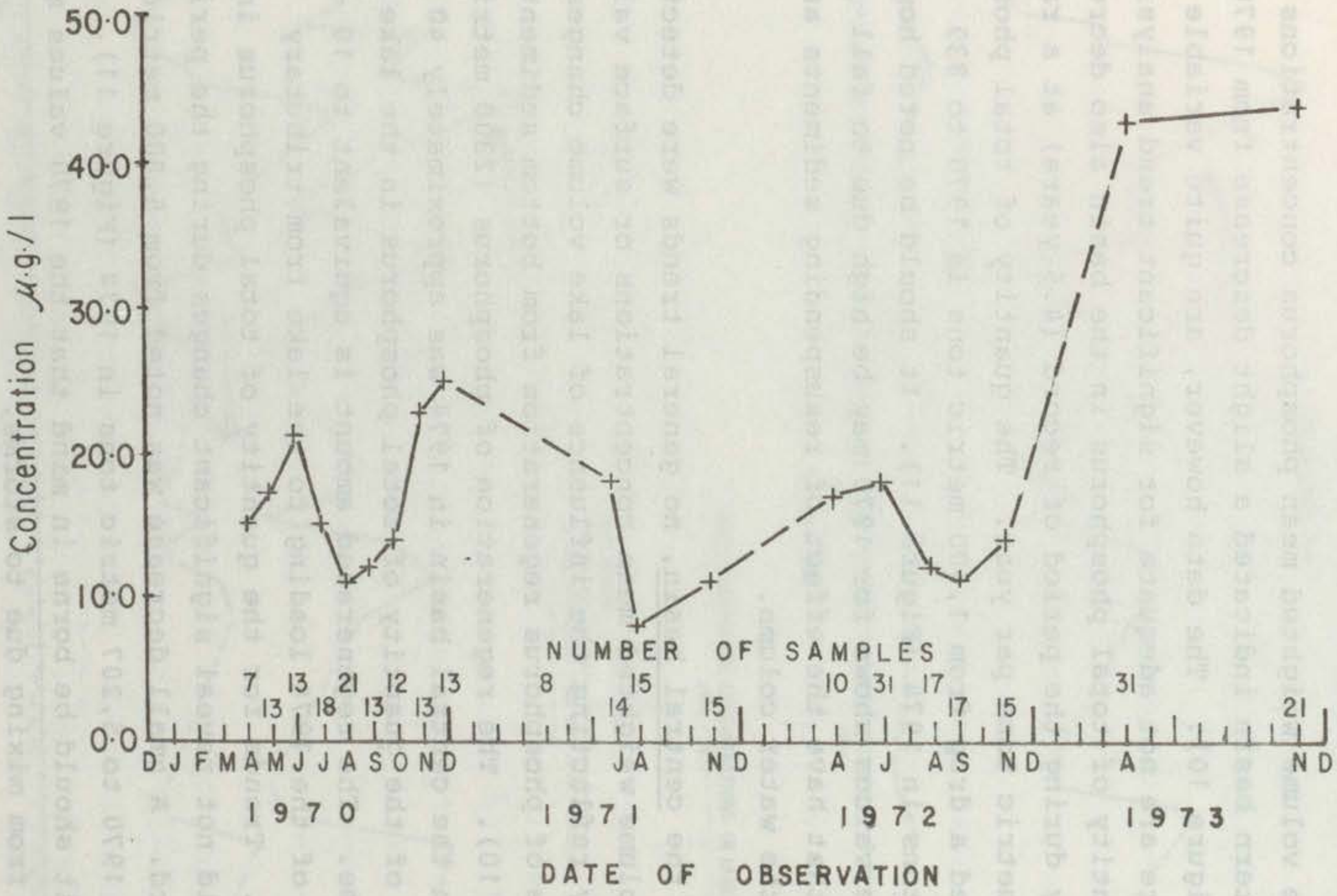
Open Lake Surface Water Values Only

FIGURE 8

Data Sources:

1970-73 Canada Centre For Inland Waters

1973-74 Centre For Lake Erie Area Research Ohio State University



TOTAL PHOSPHORUS CONCENTRATION

LAKE ERIE EASTERN BASIN

Open Lake Surface Water Values Only

FIGURE 9

Phosphorus levels in the western basin did not reveal significant changes with the exception of summer levels where a significant decrease of 4 μg/l per year (at 95 percent confidence limit) has occurred in the period 1970-74.

The volume weighted mean phosphorus concentrations in the western basin indicated a slight descrease from 1970 to 1974 (Figure 10). The data however, are quite variable and therefore are not adequate for significant trend analysis. The quantity of total phosphorus in the basin also decreased slightly during the period of record (4.5 years) at a rate of 125 metric tons per year. The quantity of total phosphorus exhibited a drop from 1,400 metric tons in 1970 to 839 metric tons in 1974 (Figure 11). It should be noted however, that the values shown for 1970 may be high due to fall storms that have the effect of resuspending sediments and mixing the water column.

In the central basin, no general trends were detected using volume weighted mean concentrations or surface values, probably reflecting the influence of lake volume changes and the rate of phosphorus regeneration from bottom sediment (Figure 10). The regeneration of phosphorus (2300 metric tons) in the central basin in 1974 was approximately 40 percent of the quantity of total phosphorus in the lake at that time. The regenerated amount is equivalent to 10 - 15 percent of the 1974 loading to the lake from tributary sources. Trends for the quantity of total phosphorus in the basin did not reveal significant changes during the period of record. A small decrease was noted from 5,800 metric tons in 1970 to 5,207 metric tons in 1974 (Figure 11). Again, it should be borne in mind that the 1970 values may be high from mixing due to storms.

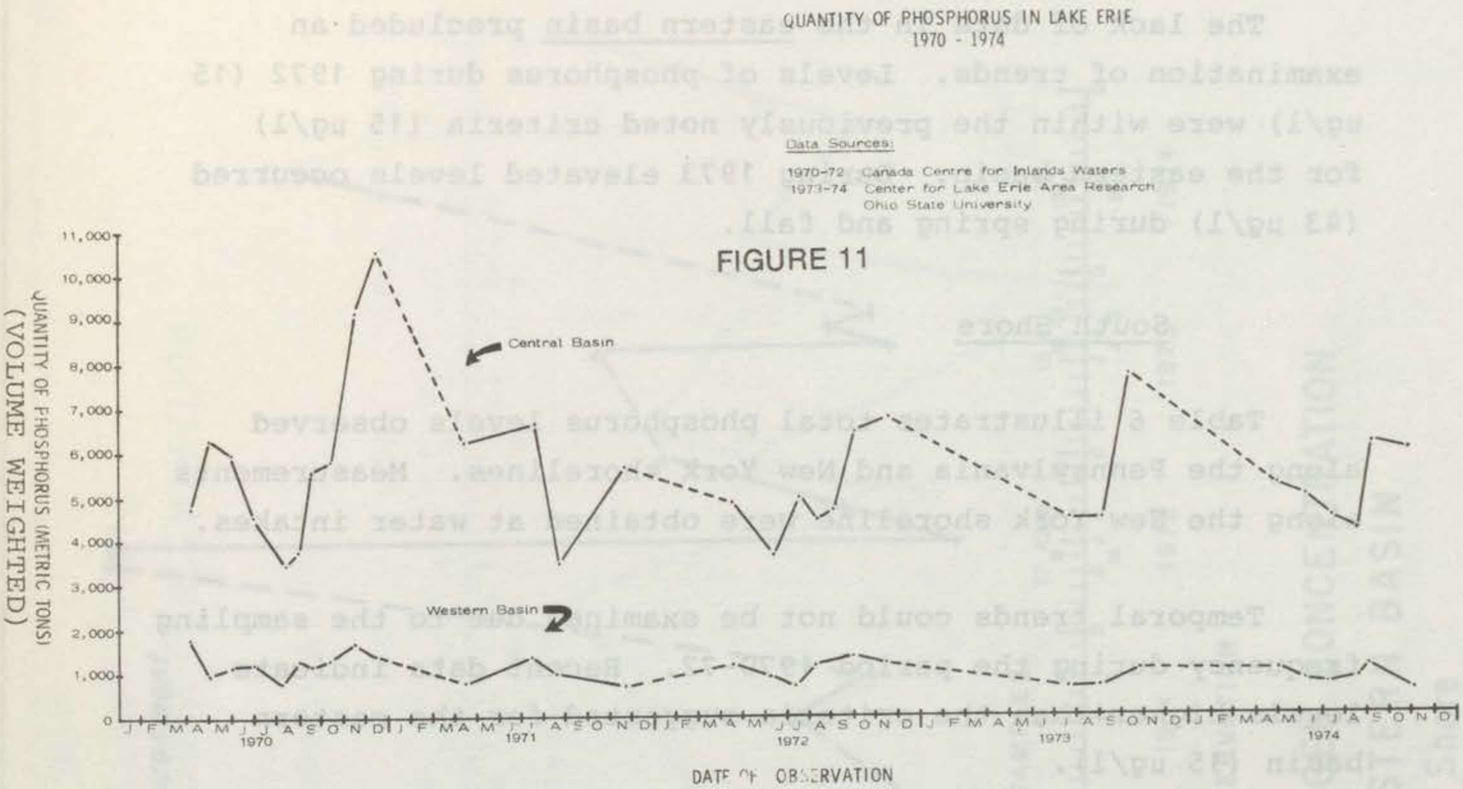


FIGURE 11

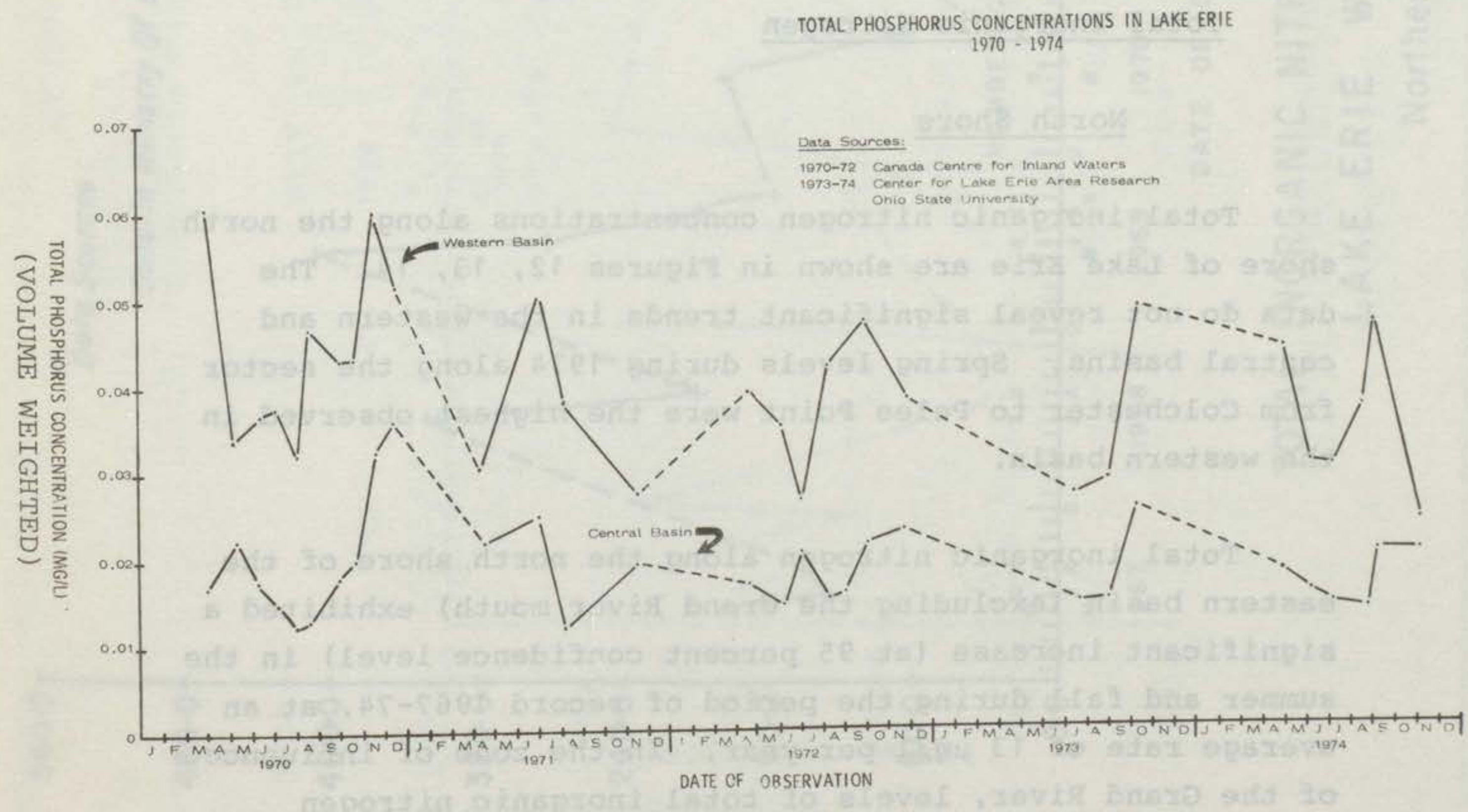


FIGURE 10

The lack of data in the eastern basin precluded an examination of trends. Levels of phosphorus during 1972 (15 μg/l) were within the previously noted criteria (15 μg/l) for the eastern basin. During 1973 elevated levels occurred (43 μg/l) during spring and fall.

South Shore

Table 6 illustrates total phosphorus levels observed along the Pennsylvania and New York shorelines. Measurements along the New York shoreline were obtained at water intakes.

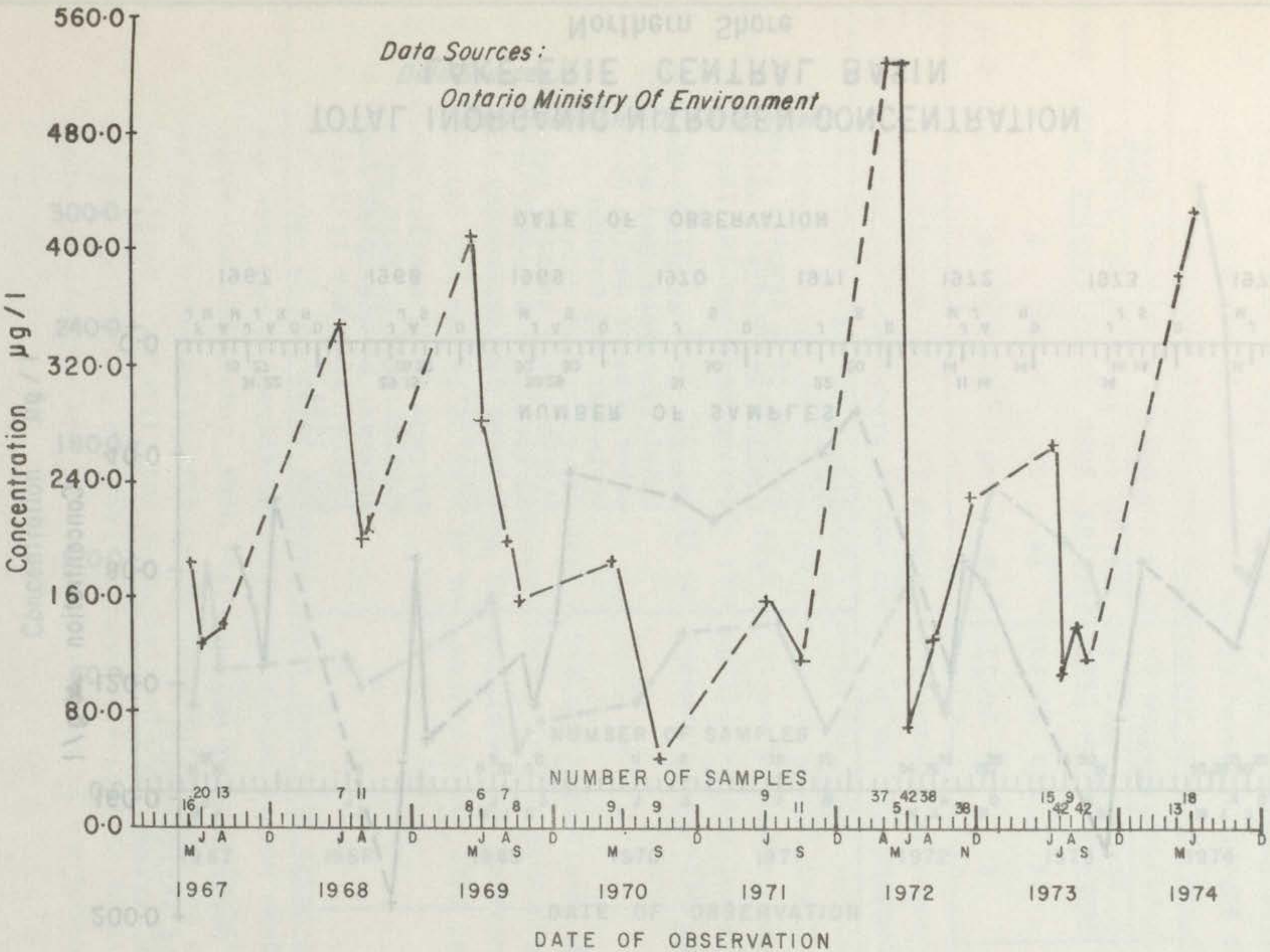
Temporal trends could not be examined due to the sampling frequency during the period 1970-72. Recent data indicate levels higher than the criteria suggested for the eastern basin (15 μg/l).

Total Inorganic Nitrogen

North Shore

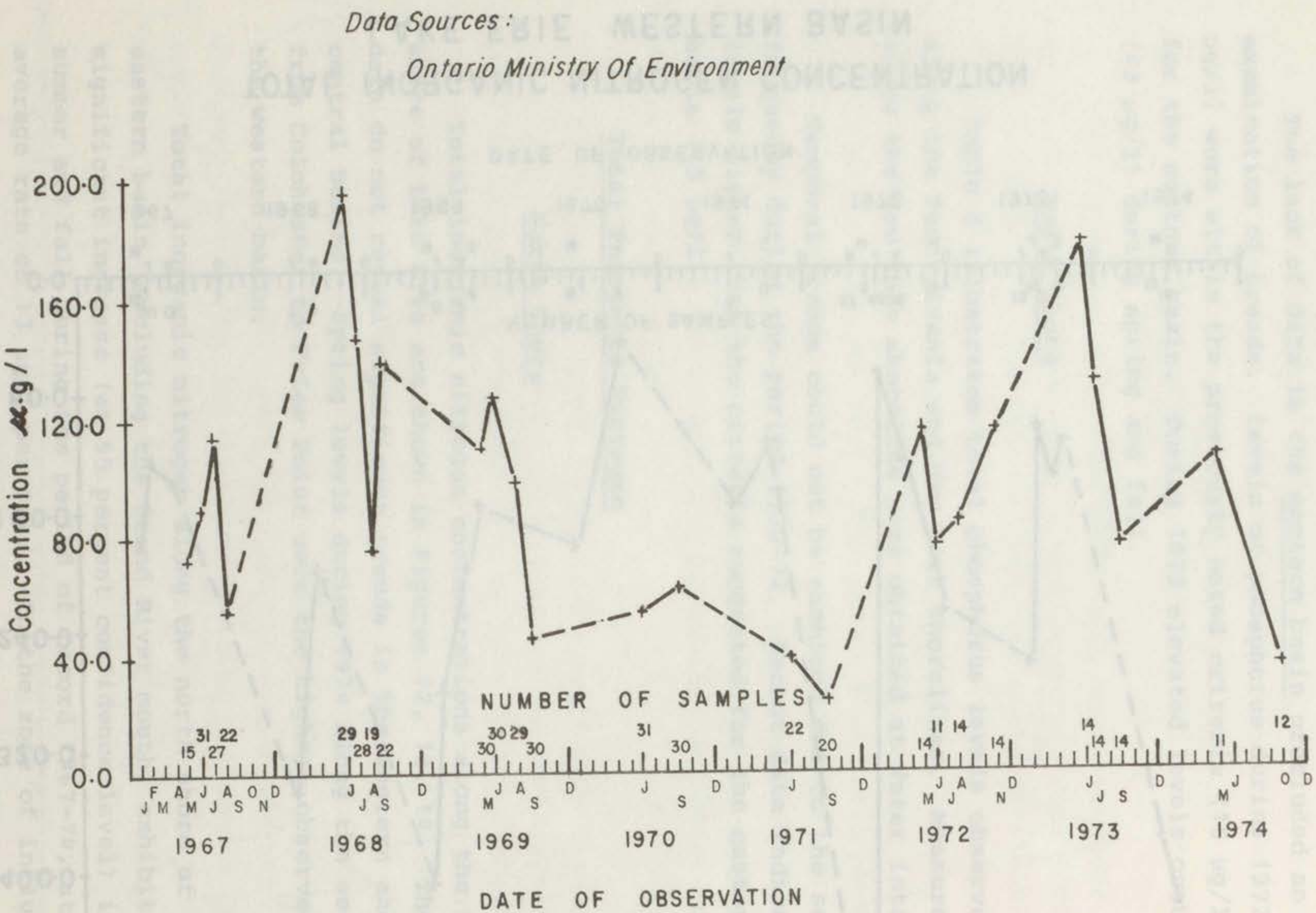
Total inorganic nitrogen concentrations along the north shore of Lake Erie are shown in Figures 12, 13, 14. The data do not reveal significant trends in the western and central basins. Spring levels during 1974 along the sector from Colchester to Pelee Point were the highest observed in the western basin.

Total inorganic nitrogen along the north shore of the eastern basin (excluding the Grand River mouth) exhibited a significant increase (at 95 percent confidence level) in the summer and fall during the period of record 1967-74, at an average rate of 13 μg/l per year. In the zone of influence of the Grand River, levels of total inorganic nitrogen



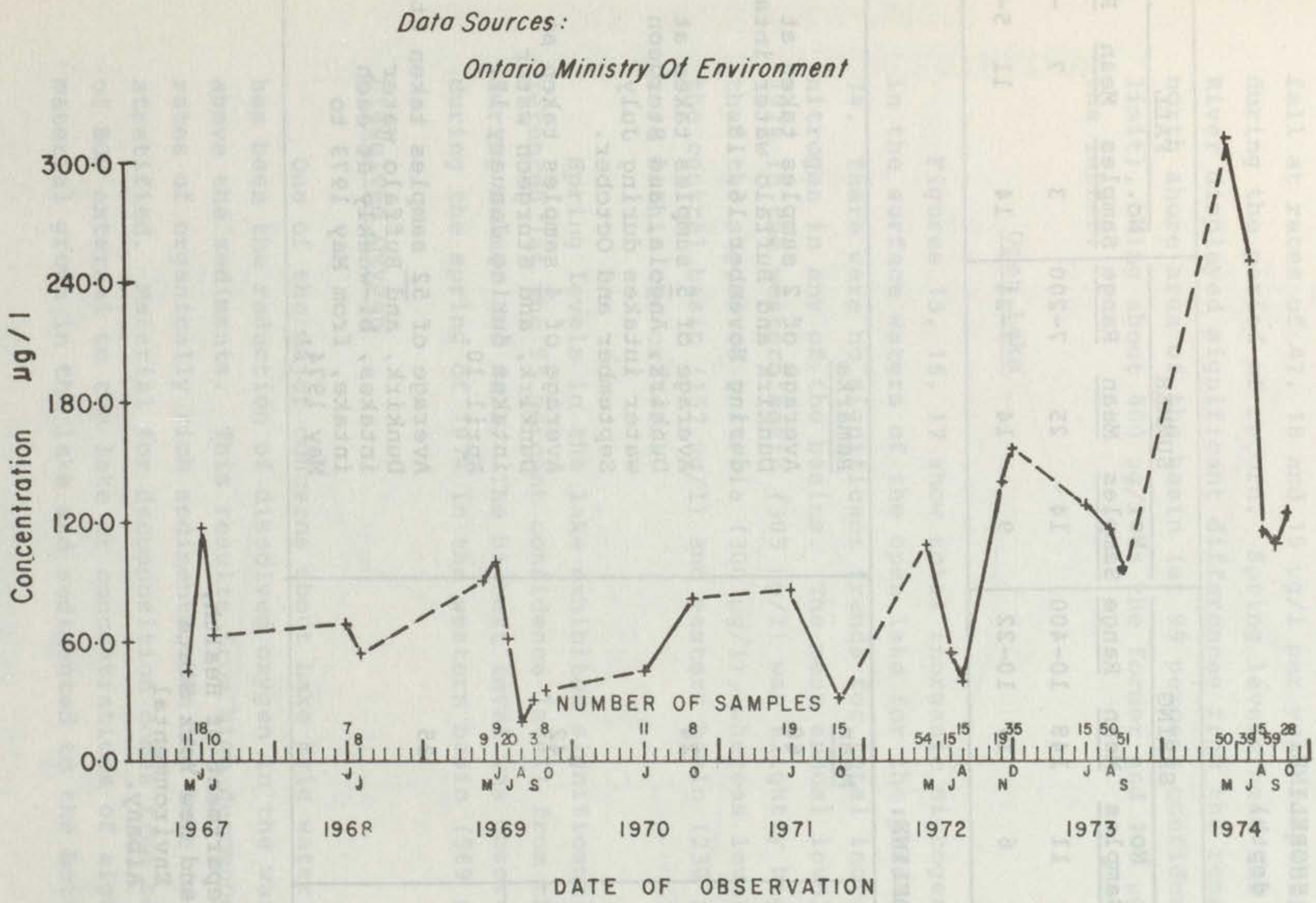
TOTAL INORGANIC NITROGEN CONCENTRATION
LAKE ERIE WESTERN BASIN
Northern Shore

Figure 12



TOTAL INORGANIC NITROGEN CONCENTRATION
LAKE ERIE CENTRAL BASIN
Northern Shore

FIGURE 13



TOTAL INORGANIC NITROGEN CONCENTRATION
LAKE ERIE EASTERN BASIN
Northern Shore

Figure 14

TABLE 6

TOTAL PHOSPHORUS (P) μg/l

PENNSYLVANIA SHORELINE:

(at mid depth)

	SPRING			SUMMER			FALL		
Year	No. Samples	Mean	Range	No. Samples	Mean	Range	No. Samples	Mean	Range
1973	11	148	10-400	14	25	7-200	3	7	-
1974	6	17	10-22	9	14	7-24	14	11	5-16

NEW YORK SHORELINE:

Year	Mean	Remarks
1970	60	Average of 2 samples taken at Dunkirk and Buffalo water intakes during November 16, 18.
1971	24	Average of 5 samples taken at Dunkirk, Angola, and Sturgeon water intakes during July, September and October.
1972	42	Average of 4 samples taken at Dunkirk, and Sturgeon water intakes during January 17, April 10.
1974	35	Average of 52 samples taken at Dunkirk, and Buffalo water intakes, bi-weekly at each intake, from May 1973 to May 1974.

DATA SOURCES:

Erie County Department of Health, Pennsylvania and New York State Department of Environmental Conservation, Albany.

exhibited significant increases during spring, summer and fall at rates of 47, 18 and 15 μg/l per year respectively during the period of record. Spring levels near the Grand River displayed significant differences from the remaining north shore area of the basin (at 99 percent confidence limit), being about 400 μg/l in the former and 300 μg/l in the latter.

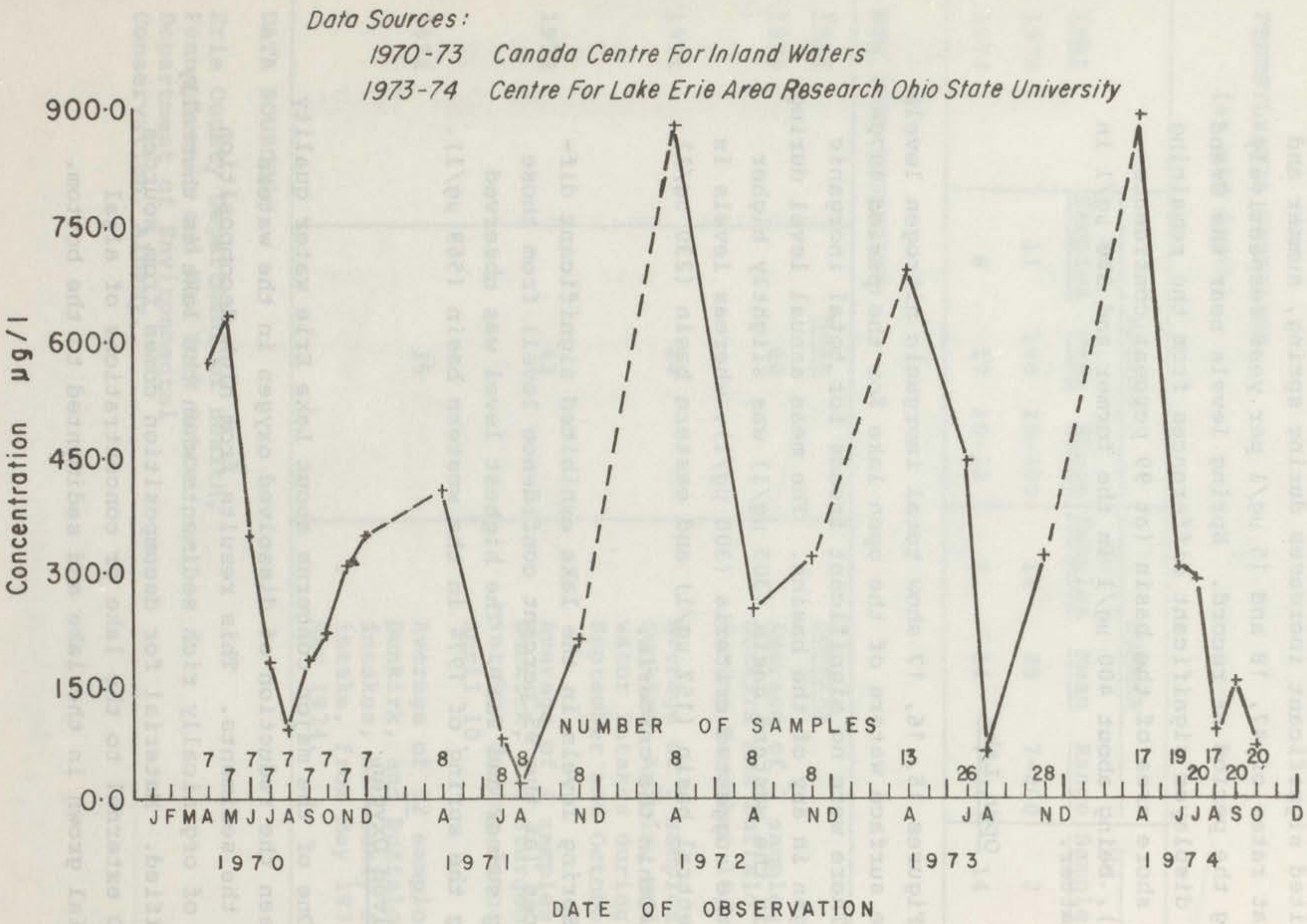
Open Lake

Figures 15, 16, 17 show total inorganic nitrogen levels in the surface waters of the open lake for the period 1970-74. There were no significant trends for total inorganic nitrogen in any of the basins. The mean annual level during 1974 in the western basin (305 μg/l) was slightly higher than the suggested criteria (300 μg/l), whereas levels in the central basin (157 μg/l) and eastern basin (230 μg/l) were within the criteria.

Spring levels in the lake exhibited significant differences (at the 95 percent confidence level) from those during summer and fall. The highest level was observed during the spring of 1974 in the western basin (569 μg/l).

Dissolved Oxygen

One of the major concerns about Lake Erie water quality has been the reduction of dissolved oxygen in the waters above the sediments. This results from high decomposition rates of organically rich sediments when the lake is thermally stratified. Material for decomposition comes from sources of BOD external to the lake or concentrations of algal material grown in the lake and sedimented to the bottom.

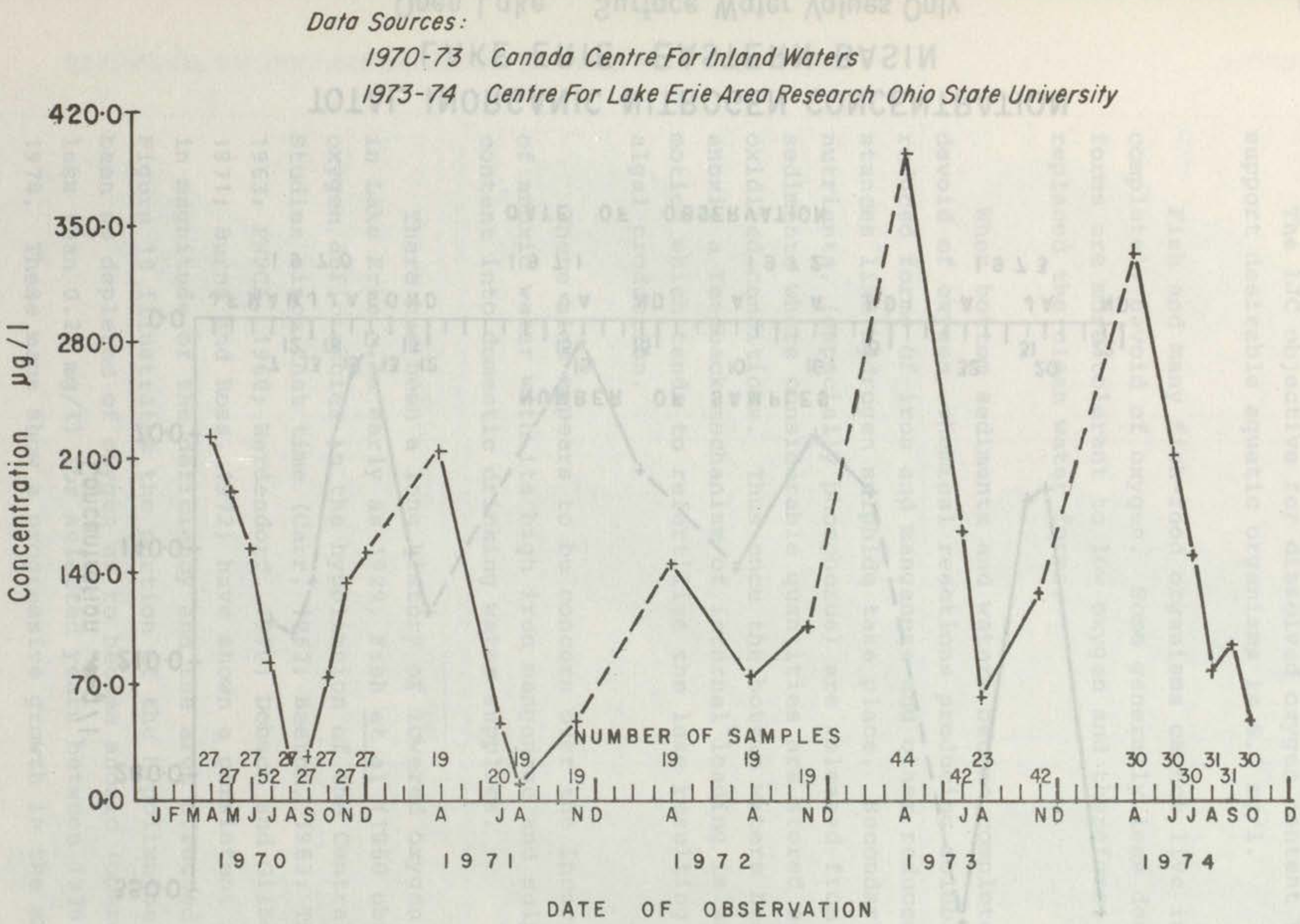


TOTAL INORGANIC NITROGEN CONCENTRATION

LAKE ERIE WESTERN BASIN

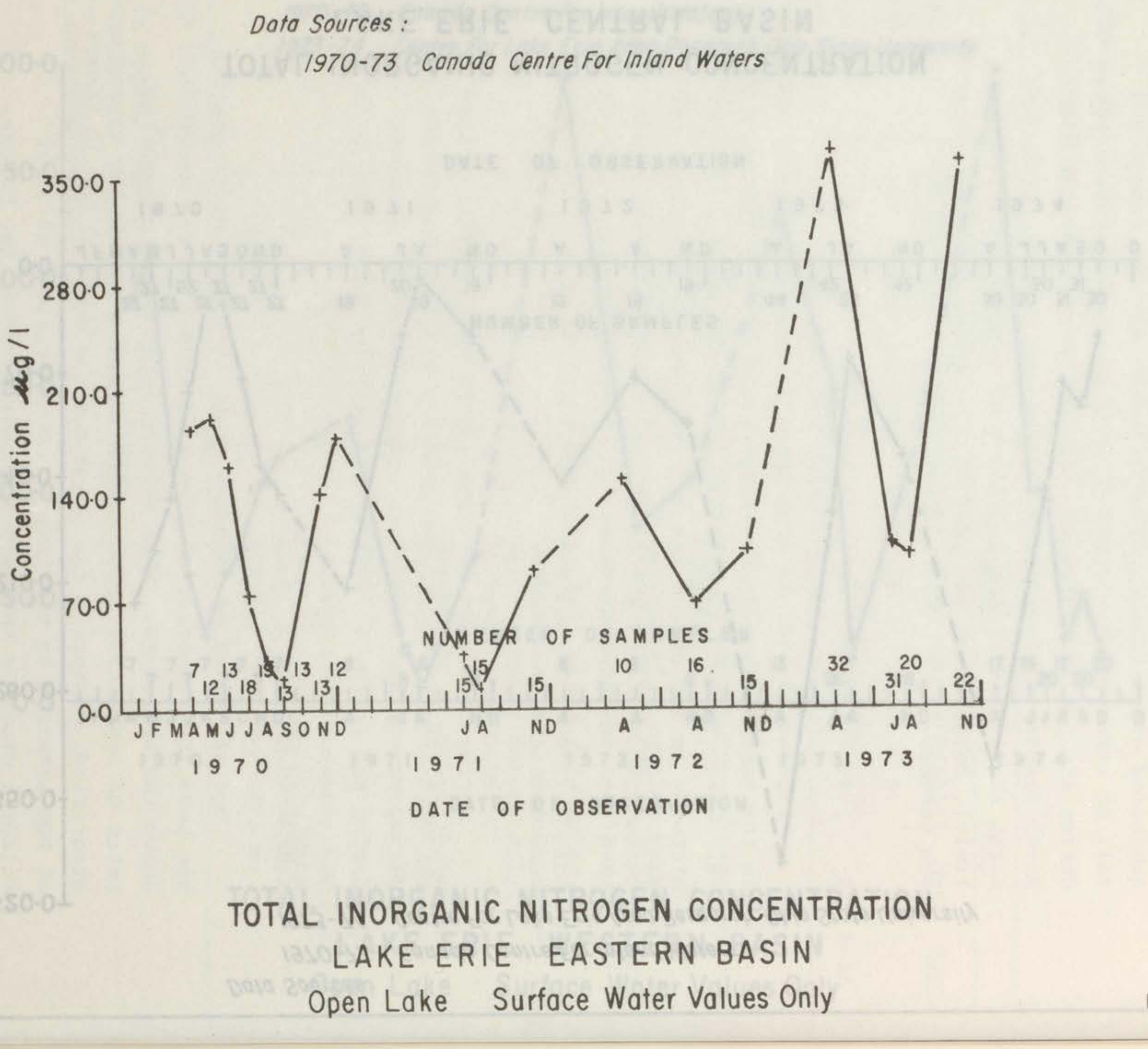
Open Lake Surface Water Values Only

Figure 15



TOTAL INORGANIC NITROGEN CONCENTRATION
LAKE ERIE CENTRAL BASIN
Open Lake Surface Water Values Only

Figure 16



TOTAL INORGANIC NITROGEN CONCENTRATION
LAKE ERIE EASTERN BASIN
Open Lake Surface Water Values Only

FIGURE 17

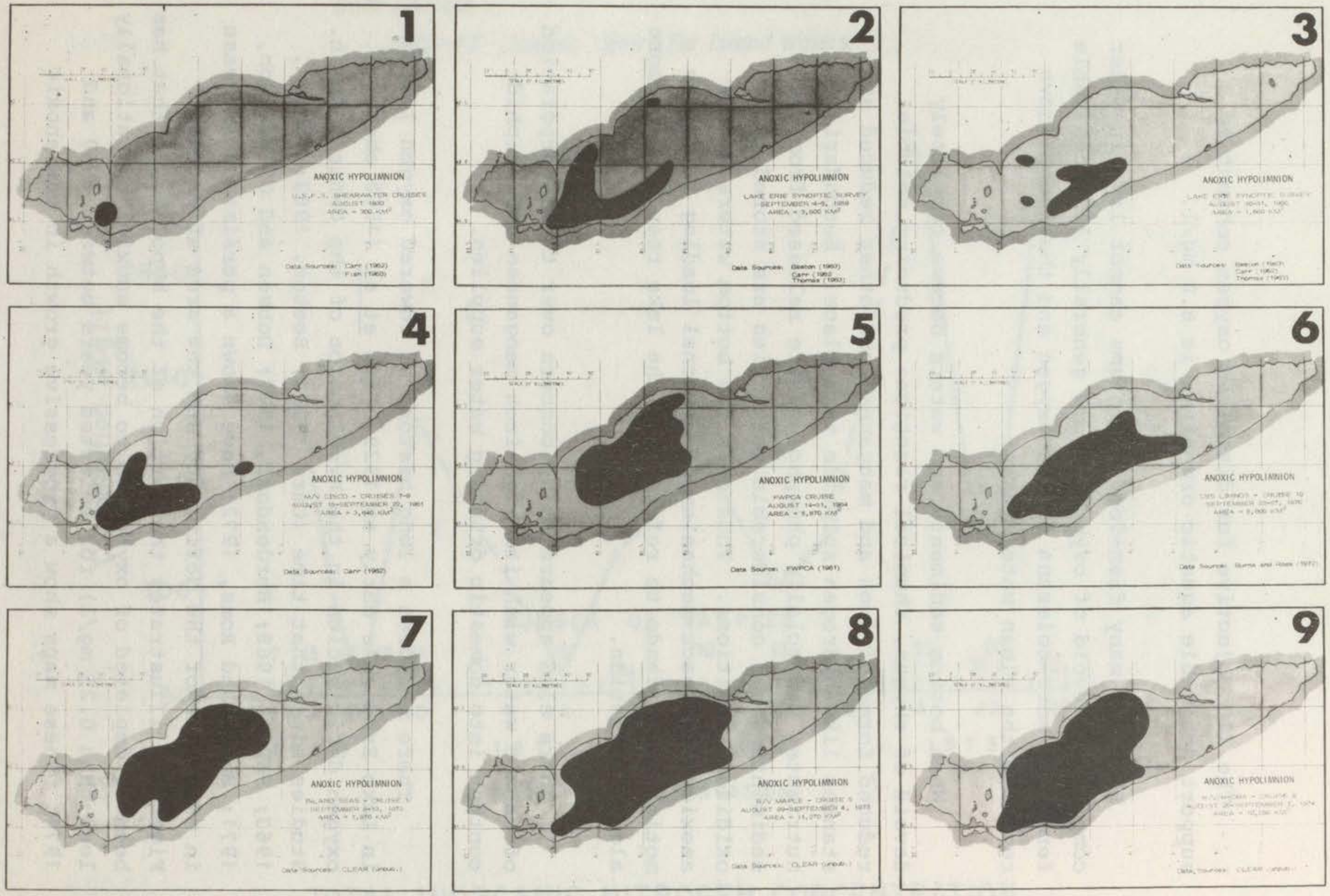
The IJC objective for dissolved oxygen content to support desirable aquatic organisms is 6.0 mg/l.

Fish and many fish-food organisms cannot live in water completely devoid of oxygen. Some generally less desirable forms are more tolerant to low oxygen and therefore, have replaced the clean water forms.

When bottom sediments and waters become completely devoid of oxygen, chemical reactions producing soluble reduced forms of iron and manganese and other reduced substances like hydrogen sulphide take place. Secondarily nutrients, (especially phosphorus) are released from the sediments where considerable quantities are stored under oxidized conditions. Thus once the bottom waters become anoxic a feedback mechanism of internal loading is set in motion which tends to refertilize the lake resulting in more algal production.

There also appears to be concern over the incorporation of anoxic water with its high iron manganese and sulphide content into domestic drinking water supplies.

There has been a long history of lowered oxygen levels in Lake Erie. As early as 1929, Fish et al (1960 observed oxygen deficiencies in the hypolimnion of the Central Basin. Studies since that time (Carr, 1962; Beeton, 1963; Thomas, 1963; FWPCA, 1968; Herdendorf, 1970; Dobson and Gilbertson, 1971; Burns and Ross, 1972) have shown a persistent increase in magnitude of the deficiency and the area affected. Figure 18 illustrates the portion of the hypolimnion that has been so depleted of oxygen as to become anoxic (operationally less than 0.25 mg/l) for selected years between 1930 and 1974. These maps show a progressive growth in the anoxic



EXTENT OF ANOXIC HYPOLIMNION IN LAKE ERIE (1930-1974)

FIGURE 18

area of the central basin from less than 2 percent in 1930 to nearly 70 percent in 1972. Trends in the anoxic area are given in Table 7. By 1973 over 93 percent of the hypolimnion area had complete oxygen depletion. It should be noted that the whole depth of the thin hypoliminion (3-5 m) is anoxic, not just a thin layer over the sediments. By the early 1950's oxygen depletion has been reported in the bottom waters of the western basin.

Several methods are used to report the low dissolved oxygen conditions in Lake Erie; minimum concentrations (approaching 0 mg/l), the extent and duration of low levels of oxygen and oxygen depletion rates. The latter attempt to take into consideration both the consumption of oxygen, and the gain in oxygen to the hypolimnion from exchanges with the water column, other basins and tributaries.

Dissolved oxygen concentrations in the western basin of Lake Erie for 1973 and 1974 were lowered to less than 6 mg/l from June to September during periods of temporary stratification. In each of these years, over 50 percent of the basin experienced this conditions. In June and August 1973 the dissolved oxygen level in the central and northeastern sections of the basin was depleted to less than 1 mg/l. Depletion was not as severe in 1974. The lowest concentrations were observed in Pigeon Bay (northeastern part of basin) during July and August where they did not fall below 3 mg/l.

Because stratification is so temporary in the western basin, adequate measurements of the oxygen deficit were not possible. Carr et al (1965) estimated that in 1963 only 5 days of stratification were required to reduce hypolimnion dissolved oxygen to 3 mg/l in this basin, whereas, 28 days

TABLE 7

ESTIMATED AREA OF THE ANOXIC HYPOLIMNION OF THE CENTRAL BASIN OF LAKE ERIE 1930-1974

YEAR	AREA (km^2)	PERCENT OF CENTRAL BASIN Hypolimnion	Total
1930	300	3.0	1.9
1959	3,600	33.0	22.3
1960	1,660	15.0	10.3
1961	3,640	33.0	22.5
1964	5,870	53.0	36.3
1967	7,500	68.0	46.4
1970	6,600	60.0	40.4
1972	7,970	72.5	49.3
1973	11,270	93.7	69.8
1974	10,250	87.0	63.4

were needed in 1953. Near zero oxygen levels were observed in June 1973 after several days of calm weather which indicates that oxygen demand of the bottom sediments continues to be very high.

In the central basin in 1974 the first depletion was observed shortly after stratification and was most severe in the southwestern section of the basin where the lake is less than 20 metres deep. By late July and early August concentrations of less than 2 mg/l were observed throughout the northcentral part of the basin. In early September nearly all of the central basin bottom water has less than 1 mg/l. After three months of stratification, the lake cooled and overturned in mid-September resulting in dissolved oxygen levels above 6 mg/l throughout the basin.

The levels of dissolved oxygen in the eastern basin of Lake Erie did not suffer a serious depletion in 1973 or 1974. However, hypolimnion concentrations of less than 6 mg/l were observed for each month during the period July to November, less than 5 mg/l for August to October and less than 4 mg/l in August 1974 and September 1973. In 1973 the greatest areal extent of low dissolved oxygen (< 6 mg/l) occurred in mid-September and early October in the western and central sections of the eastern basin. Whereas, in 1974 the greatest area of low levels (< 6 mg/l) was found in the eastern half of the basin during mid-August and early September.

Trends in the net oxygen depletion rate for the central and eastern basins are presented in Table 8. In the hypolimnion, the oxygen concentration in the central basin was reduced approximately 0.1 mg/l per day in the summer of 1974, whereas, in the deeper eastern basin the loss rate was only

TABLE 8

TRENDS IN NET OXYGEN DEMAND OF THE CENTRAL AND EASTERN BASIN HYPOLIMNIONS OF LAKE ERIE

YEAR	NET OXYGEN DEMAND			
	Rate Per Unit Area ($mg\ O_2\ cm^{-2}\ day^{-1}$)		Rate Per Unit Volume ($mg\ O_2\ l^{-1}\ day^{-1}$)	
	Central Basin	Eastern Basin	Central Basin	Eastern Basin
1930	0.008	-	0.054	-
1940	0.015	-	0.067	-
1950	0.025	-	0.070	-
1960	0.037	-	0.093	-
1970	0.039	-	0.13	-
1973	0.023	0.023	0.12	0.012
1974	0.047	0.018	0.11	0.011

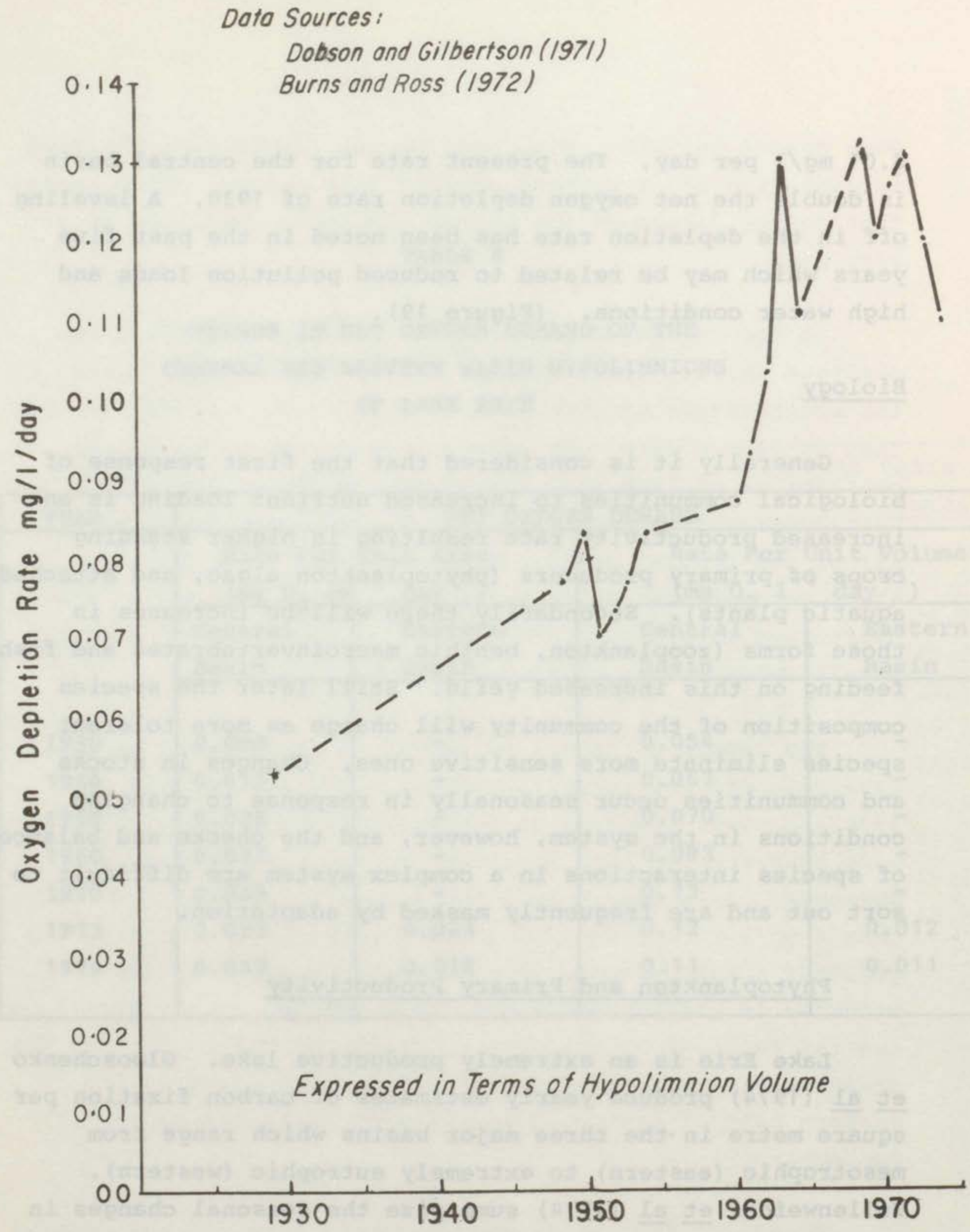
0.01 mg/l per day. The present rate for the central basin is double the net oxygen depletion rate of 1930. A leveling off in the depletion rate has been noted in the past five years which may be related to reduced pollution loads and high water conditions. (Figure 19).

Biology

Generally it is considered that the first response of biological communities to increased nutrient loading is an increased productivity rate resulting in higher standing crops of primary producers (phytoplankton algae, and attached aquatic plants). Secondarily there will be increases in those forms (zooplankton, benthic macroinvertebrates and fish) feeding on this increased yeild. Still later the species composition of the community will change as more tolerant species eliminate more sensitive ones. Changes in stocks and communities occur seasonally in response to changing conditions in the system, however, and the checks and balances of species interactions in a complex system are difficult to sort out and are frequently masked by adaptation.

Phytoplankton and Primary Productivity

Lake Erie is an extremely productive lake. Glooschenko et al (1974) produce yearly estimates of carbon fixation per square metre in the three major basins which range from mesotrophic (eastern) to extremely eutrophic (western). Vollenweider et al (1974) summarize the seasonal changes in species composition and abundance of open-lake phytoplankton in these basins in 1970 but give no historical trends because data is sporadic and not readily comparable.



MEAN DISSOLVED OXYGEN DEPLETION RATE
FOR HYPOLIMNION
LAKE ERIE CENTRAL BASIN

Figure 19

Over the short term from 1967-1973, it is possible to examine cruise mean values for chlorophyll a as an estimate of phytoplankton biomass. No general increasing or decreasing trends in abundance can be detected. (See Figure 20) These do not show any clear yearly differences or trends with time.

Estimates of nearshore phytoplankton abundance and chlorophyll a concentration were derived from selected water intake sampling in Ontario and Ohio and from coastal zone surveys carried out by the Ontario Ministry of the Environment.

Chlorophyll a concentrations along the north shore of all basins are lower than the lake mean. This may be due at least in part to a tendency for higher concentrations of temperature, chlorophyll and nutrients to be found along the south shore of the lake (Gachter et al, 1974) or higher turbidity in the nearshore area. Year to year trends in chlorophyll a concentration are not strongly marked but declines may have taken place since 1968 around Pelee Island and in isolated areas of the eastern basin shore line.

It is especially noteworthy both Ontario and Ohio report marked decreases in phytoplankton at water intakes in the western basin since 1967. Also, there have been declines in abundance of nuisance blue-green algae during the summer months.

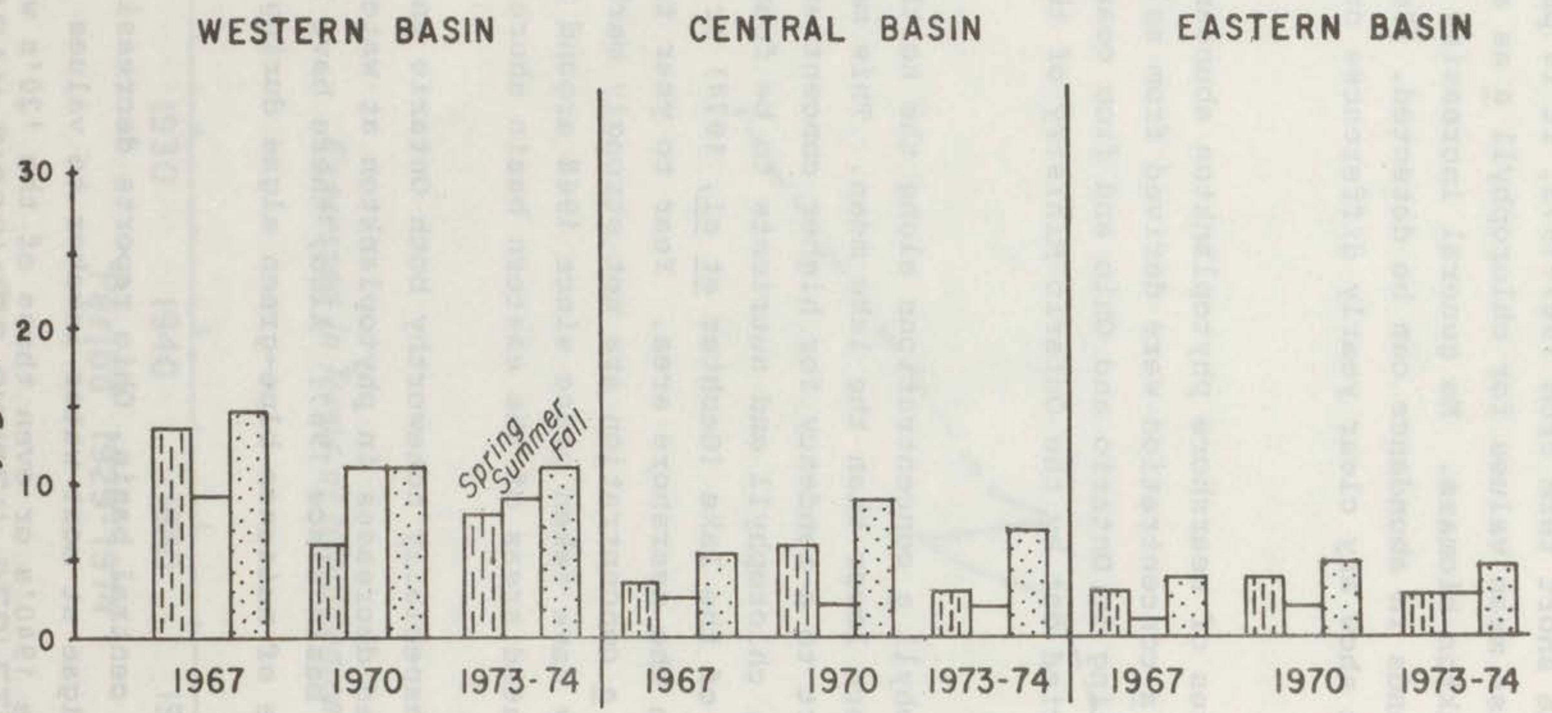
In the central basin, Ohio reports decreasing trends in cell counts of algae at most water intakes to values similar to those of the 1940's or even those of the '20's while Ontario considers values at the Blenheim intake and at the Dunnville

Data Sources:

1967: Federal Water Pollution Control Admin. (1968) - Chlorophyll reported as corrected a and b

1970: Canada Centre for Inland Waters (unpub.) - Chlorophyll reported as corrected a

1973-74 Centre for Lake Erie Area Research and Great Lakes Laboratory (unpub.) - Chlorophyll reported as corrected a



TRENDS IN SURFACE WATER CHLOROPHYLL a

LAKE ERIE MID-LAKE

1967 - 1974

Figure20

intake in the eastern basin may have increased slightly in the past few years, especially during the fall months. Some municipal water treatment plants that obtain their water supplies from the central and eastern basins noted a decline in algal related problems during 1974. This may have been due, however to a decline in the relative number of Cyanophyta rather than an absolute decrease in algal biomass.

Increases in crustacean zooplankton numbers since 1967 are less drastic than in the 15 year period prior to 1967 but maximum numbers of cladocerans recorded from the western basin and Cleveland Harbor (Watson, 1974, Rolan et al, 1974) are greater than in previous years. There have also been increases in the abundance of warm water species, including Diaptomus siciloides, Eurytemora affinis and Eubosmina coregoni in the western basin and along the south shore of the central basin.

Gannon and Beeton (1971) document the decline of the cold deepwater plankter Limnocalanus and consider than its virtual absence may be due to lack of a well oxygenated cold water habitat and to grazing pressure from planktivorous fish.

Surveys of benthic marcoinvertebrates in Lake Erie have been carried out for USEPA in 1973 by CLEAR (Cleveland) and GLL (Buffalo) and indicate some deteriorating conditions since 1967 in that the number of stations with pollution tolerant forms of oligochaetes and chironomids has increased in the central and western basins. In the eastern basin the number of stations with the pollution sensitive form Pontoporiea affinis has declined somewhat and mayfly nymphs of the genus Hexagenia have disappeared since previous surveys in 1967, when they were present at 24% of the station samples. Several oligochaete indicators of less than ideal water quality including Peloscolex ferox were reported from the eastern Basin for the first time in 1973.

There are several records of introductions of exotic organisms into Lake Erie since the 1967 report, one of these, the Chinese mitten crab, Eriocher sinensis causes considerable economic damage in Europe where it is wide-spread in river systems far distant from the sea. The damage is primarily caused through burrowing into banks and dykes which results in erosion and collapse of structures. Nepzy and Leach (1973) consider that it is unlikely to become established in Lake Erie unless forms which can reproduce in freshwater develop.

Other marine and euryhaline species reported from the lake as introductions are Coscinodiscus rothii a marine diatom (Vollenweider et al, 1974) and Bangia a sessile red alga found in assocation with Cladophora beds (Kishler and Taft, 1970). The significance of these and other new species in the Lake Erie environment is difficult to predict.

The attached macroscopic alga Cladophora is considered to be present in all suitable habitats in the Lower Great Lakes with presence limited only by availability of sub-strate, rocky outcrops, boulders and suitable man-made surfaces to a depth of 3 metres or more in Lake Erie. Despite the impact of Cladophora on beaches, water intakes and fisheries, very little quantitative data is available on production in any one area or for trends in production over time. It has been demonstrated that high water levels such as those which have prevailed over the past few years tend to decrease the area available for attachment and increased erosion and sediment load decrease light availability so that crops are expected to be less than in times of lower water levels.

There have been reports of dead alewives Alosa pseudoharengus on the beaches in the Eastern Basin, especially in Pennsylvania for several years but no specific trends are available.

Bacteriological Results

The open waters of the western basin of Lake Erie are only occasionally above objectives while the central and eastern basins of the lake seldom have violations except for isolated instances noted in the detailed agency reports.

Both Ontario and Pennsylvania have near-shore sampling programs beginning in 1967 and 1972 respectively which include bacteriological results. These programs show consistently good results with several exceptions. Ontario reported in the western basin, approximately half of the stations exceeded the 1000/100 ml total coliform objective at least once during the 1972 sampling season. In the central basin two locations near Wheatly Harbour showed elevated fall levels. The eastern basin was generally within the objectives except near Long Pont and west of Port Maitland in late summer. No direct sources have been identified and the elevated levels are generally attributed to the resuspension of bacteria from sediments . In 1973 similar observations occurred.

Ohio reported that in 1974 the annual geometric mean for fecal coliform appeared to exceed the objective at the mouths of seven tributaries. In both 1973 and 1974 the highest levels were found in the Cuyahoga River, followed by the Rocky River. The effect of these tributaries on the Lake Erie waters was not reported. The Pennsylvania surveys found no violations of the Agreement objectives offshore except for one sampling in 1972. The range of the Pennsylvania values for six stations are tabulated below. Neither the Ohio or Ontario near-shore programs identified any trends.

Coliform Ranges for Pennsylvania Offshore Stations
MPN/100 ml

Year	Total	Fecal
*1972	0 - 1100	0 - 50
1973	0 - 40	0 - 20
1974	0 - 374	0 - 17

* One Station

Ohio water intake bacteriological data for the period 1968-1972 reflected substantial improvement or maintenance at levels within the objectives except for trouble spots at Lorain and Port Clinton which were thought to be caused by contaminated rivers.

Trend information for bacteriological data involving beach sampling is available from both Ohio and Pennsylvania. Both states report a continuation of an improving trend first noted in Pennsylvania between 1969 and 1970 and in Ohio between 1971 and 1972. The data used in establishing the existence of the trends is tabulated in Table 19. Both states attribute the improvement to pollution abatement measures taken in the immediate vicinity of the affected beaches.

TABLE 19

Lake Erie Beach Evaluation and Comparison

Year	Coliform Counts (MPN/100 ml) Pennsylvania (11 beaches)		Ohio (20 beaches)**	# Times Monthly Geo. Mean Exceeded 200 MPN/100 ml	
	Total	Fecal	Fecal	Penna.	Ohio
1961	*3620			N.A.	
1962	*4900			N.A.	
1963	*1646			N.A.	
1965	+3425			N.A.	
1967	1262			N.A.	
1968	454			N.A.	
1969	2114	98			
1970	187	35			
1971	348	91	132		10
1972	547		77	N.A.	10
1973		33	87		7
1974		30	64	0	5

* Beach 11 Samples Only

\+ Beach 1 & 11 Samples Only

** Sampled Extensively during Summer months

N.A. Not Available

pH

Objectives established by the IJC in 1972 for pH specify that values should not lie outside the 6.7 to 8.5 range. Data submitted by the various agencies from early 1972 to the end of September, 1974, show that the northern shore of the central section was the only area consistently meeting the objectives. The other areas were frequently in excess of the upper limit especially in the spring and summer. The most important note regarding pH values during this period in Lake Erie water appears to be the correlation to the distribution patterns of nutrient concentrations, algal accelerated growth periods, and chlorophyll a levels.

The data submitted by the Ontario Ministry of the Environment was collected in surface nearshore waters of the northern shore during four cruises from April to December, 1972. The cruises involved sampling of approximately 100 stations encompassing the entire northern shore and western basin island area. In the eastern basin, the spring values exceeded the upper limit at all stations east of the Grand River, but during the other three cruises pH values in the eastern basin were within the IJC objective. The central basin was found to be almost entirely within the objective throughout the year while the western basin showed levels exceeded the objective in the sector between Kingsville and Pelee Point and at Pelee Island especially in the spring and summer. High pH levels in these areas parallel the high chlorophyll a values recorded there, suggesting that increased productivity in these waters is responsible for the pH rise. Near the mouth of the Detroit River, two stations showed pH values below the 6.7 recommended limit. Industrial effluent discharged into the Detroit River was likely the cause of the depressed level.

Ohio's nearshore water quality was examined using data obtained from the Water Intake Monitoring Program which was initiated in 1968 and is a continuing program. The pH data from the tributary sampling stations is also included to reflect any influence on the Lake.

The Ohio EPA Lake Erie Tributary sampling program consists of regular grab samples at gauging stations near the mouth (but above the estuary effect) of twelve (12) tributaries. The pH for all tributaries was within Ohio Water Quality Standards during both water years 1973 and 1974 as given in Table 10 below showing minimum and maximum values. The 1973 minimum pH values for the Portage and Vermillion Rivers were both field measurements on a single day and all other values for both tributaries are greater than 6.0.

The Ohio Water Intake Program is a joint effort on the part of the OEPA and sixteen (16) municipal water treatment plants withdrawing water from Lake Erie.

A review of the Ohio Intake Data shows that the upper limit of 8.5 pH is frequently exceeded, especially in the central and western basins. The preponderence of the high values occur in late spring and throughout the summer, often extending through September. An overview of the data does not indicate a discernible trend for the three year period of 1972-73-74. (Table 11).

Maximum pH values of 9.0 may occur from Mentor-on-the-Lake west to Toledo with several of the stations reporting values in excess of 8.5 for twenty percent or more of their samples over the year.

TABLE 10

OHIO TRIBUTARIES - pH

Tributary	1974 pH Levels Min.	Max.	1973 pH Levels Min.	Max.
Maumee River	7.1	8.5	6.6	8.3
Portage River	6.3	8.95	5.5	8.4
Sandusky River	6.8	8.91	6.5	8.3
Huron River	6.5	8.1	8.1	8.1
Vermillion River	6.6	8.5	5.0	8.6
Black River	6.0	8.5	7.1	7.8
Rocky River	6.5	7.7	6.0	8.0
Cuyahoga River	6.0	7.7	6.5	7.6
Chagrin River	6.0	8.0	6.2	8.3
Grand River	6.0	7.9	6.0	7.2
Ashtabula River	6.0	7.8	6.0	7.7
Conneaut Creek	6.0	7.9	6.0	7.4

TABLE 11

OHIO WATER INTAKE DATA

WESTERN BASIN

Intake Location	Time Period	# of Samples	% of Samples Exceeding 8.5 pH	Maximum pH
Toledo	1/3/72 to 12/31/73	506	24%	9.0
Port Clinton	1/1/72 to 9/30/74	1,371	1%	8.7
CENTRAL BASIN				
Sandusky	1/1/72 to 6/9/74	243	46%	9.2
Huron	1/3/72 to 9/30/74	244	2%	9.0
Lorain	1/1/72 to 9/30/74	303	25%	8.9
Elyria	1/1/72 to 9/30/74	335	3%	8.8
Avon Lake	1/1/72 to 9/30/74	869	7%	8.9
Crown (Cleve.)	1/3/72 to 9/30/74	336	1%	8.9
Division (Cleve.)	1/3/72 to 8/30/74	215	5%	8.7
Nottingham (Cleve.)	11/9/72 to 9/30/74	461	4%	8.8
Mentor-on-the-Lake	1/1/72 to 9/30/74	302	15%	8.9
Painesville	1/1/72 to 9/30/74	905	9%	8.8
Madison-on the-Lake	1/1/72 to 11/30/73	332	4%	8.6
Conneaut	1/1/72 to 9/30/74	935	1%	8.6

During the 1974 season, the Pennsylvania Erie County Department of Health supported by a grant from both the Ford Foundation and the Pennsylvania Department of Environmental Resources, continued the monitoring program of Lake Erie off the shores of Pennsylvania. The same eight stations monitored in 1973 were monitored again in 1974. Two of those stations are located seven and ten miles offshore and are located as follows; one in the connecting channel between the middle and eastern basins of Lake Erie and one in the extreme southwest section of the eastern basin with a depth of 40 meters. Four of the stations are located approximately a thousand yards offshore interspersed along the entire shoreline with a depth of approximately 10 meters. The final two stations are located one in the Bay and one in the mixing zone outside of the Bay where the various discharge outfalls are located with a depth of approximately 10 metres. The first two stations were located in order to determine the existing water quality of the open lake in the vicinity of Pennsylvania. The four nearshore stations were located to determine the immediate effect of lake water quality on the Pennsylvania shoreline and the effect of Pennsylvania discharges on the lake quality. The last two stations were located to determine the immediate effects on water quality due to discharges from Pennsylvania. All stations were sampled at the top, midpoints and bottom positions.

The pH values of all stations were occasionally above the IJC objective of 8.5 while the three stations west of the entrance to Presque Isle Bay and without the Bay were consistently so.

Toxic Materials

At present, the availability of data for toxic materials for the assessment of Lake Erie is rather limited, but the existing information indicates that the quality of the water in this regard is generally good.

Metals

Water quality data for 1974 along the Pennsylvania shoreline indicates mercury, lead, cadmium and chromium were, for the most part, undetectable. Copper was present occasionally in amounts above a 20 μg/l level (state criterion) at most stations. As opposed to the trend to lower values towards the east in the 1973 survey, in 1974 the mean copper concentrations were quite uniform over the entire study region. No statistical differences were noted between the 1973 and 1974 seasons for heavy metal concentrations.[1]

Harbor sediment samples have been taken at various locations in Lake Erie and limited heavy metal analyses were done. While sediment content does not reflect water quality per se it does indicate areas affected by human activity. The criteria used to compare sediment quality are those promulgated by the U.S. EPA as quidelines for evaluation of proposals and applications to dredge sediments (guidelines are presently under review and may be revised).

One the Canadian shoreline of Lake Erie three harbors sampled (namely Kingsville, Leamington and Port Stanley) have information for zinc and mercury which is summarized

[1]Selected Analysis and monitoring of Lake Erie Water Quality including the Limnology of the Benthos of Presque Isle Bay. Annual Report 1974 submitted to Erie County Health Dept. By the Great Lakes Research Institute. December 31, 1974.

Table 12.[2] The minimum and maximum figures represent values from differing station locations.

On the American shoreline similar information is reported for Barcelona, Dunkirk and Buffalo.

As a whole, Barcelone Harbor sediments did not exceed the EPA criteria when sampled in June 1972. The mercury level was near the criterion in the harbor center. From previous data it appears that levels of chemical pollutants in sediments have greatly decreased from 1970 to 1972.

Dunkirk Harbor sediment in 1972 was classed as polluted. Lead and zinc were within the criteria, (the criterion for lead is 50 mg/kg) but an elevated mercury level was found. 1971 data indicate approximately the same extent of contamination evident in 1972.

Buffalo harbor sediments in 1972 remained grossly polluted although the level of pollution has decreased since 1969. Lead and zinc criteria were not violated however mercury was.[3]

The ministry of the Environment sampled surface sediments at eleven stations (twenty-four stations for mercury) throughout the western basin of Lake Erie. Table 13 presents a summary of the information obtained from this survey. The results appeared to reflect source inputs from all areas of the

[2]International Working Group on the Abatement and Control of Pollution from Dredgin Activities. First Report, April, 1974.

[3]Sediment Quality of the Great Lakes Dredged Harbors in New York State 1972-1973. U.S. Environmental Protection Agency Region II, Rochester Field Office, Rochester, New York. December 1973.

basin and a gradient existed with the highest concentrations near the Detroit River mouth and sources in the western end of the basin.

Radioactivity

The waters of the Great Lakes have always held very low concentrations of radioactivity arising from leaching of natural radioactive minerals of uranium and thorium in sediments and shorelines.

The entry of radionuclides produced by nuclear fission into the Great Lakes System started to become appreciable in 1954 and reached a peak in 1963 as a result of fussion bomb testing. Since then, the levels in lake waters have declined due to radioactive decay and flushing processes. In 1973 the maximum level of strontium 90 determined in the open waters of Lake Erie was 1.1 $pCi/_l$.[4] Present Ohio EPA water quality standards specify 10 $pCi/_l$ as the maximum acceptable level for strontium 90.

Radioactivity levels reported by Ohio indicated radioactivity levels for both alpha and beta activity did not exceed state water quality standards in any of the twelve tributaries monitored during 1974. No alpha activity was detected and the highest levels of beta activity occurred in the Black and Maumee Rivers. In 1973 the data indicated generally higher levels of beta activity and alpha activity in the Maumee, Cuyahoga, Black and Rocky Rivers. In each

[4] Second Report of the Radioactivity Work Group to the Great Lakes Water Quality Board of the International Joint Commission. March 5, 1975.

case the maximum level of alpha activity found in 1973 (14.0, 9.0 6.0 and 6.0 respectively) exceeded the state standard of 3 $pc/_{l}$ [5]; however all average values fell below this level.

Pesticides

While pesticides appear to be undetectable in the open waters of Lake Erie, as evidenced by information reported for Pennsylvania, studies of pollutants in breeding Herring Gulls, indicates contamination of this type does exist.

This contamination was evident from reproductive failures which were characterized by poor hatchability of the eggs and by eggshell breakage and flaking. Eggs analyzed for organochlorine substances showed severe contamination with DDE and PCB. Eggshell thinning was found in all the colonies studies in the lower Great Lakes, but was greatest in Lake Ontario and was correlated with the content of DDE in the eggs. The breeding success of Herring Gulls, indicated by the number of fledged young per/pair, ranged from 0.06 to 0.21 for colonies in Lake Ontario and from 0.35 to 0.52 for Lake Erie.[6]

[5] Detailed Assessment of Water Quality in Ohio Lake Erie Tributaries and their Pollution Loadings to Lake Erie. Ohio EPA for the Annual Report to the Great Lakes Water Quality Board of the International Joint Commission.

[6] Gilbertson, Michael. Pollutants in Breeding Herring Gulls in the Lower Great Lakes. The Canadian Field Naturalist. Vol 88, no. 3. July - September 1974.

Volatile Organics[7]

A joint federal/state survey of organics in drinking water supplies was done within Region V of USEPA. The results of seven analyses for the cities of Detroit, Toledo and Cleveland are presented in Table 14. There are currently not enough data to fully understand either the normal background level or the health significance of the organic compounds included in this study. With perhaps the exception of chloroform, concentrations of organics analyzed in these drinking waters should not be considered atypical.

The formation of chloroform, it appears, if effected by chlorine application. Concentrations of chloroform in water supplies with a high chlorine demand may exceed 0.1 milligram per litre. However, this level should not be considered to present an imminent rish to health.

[7] Region V Joint Fereral/State Survey of Organics in Drinking Water. Preliminary Draft. April 1, 1975.

TABLE 12

HARBOR SEDIMENTS - HEAVY METALS

HARBOR	DATE OF SAMPLING	METAL	CONCENTRATION (mg/kg)	
			MINIMUM	MAXIMUM
CANADA				
Kingsville	May 22, 1970	Zn	47.5	124
		Hg	0.22	0.78
Leamington	May 17, 1970	Zn	45	90
		Hg	0.04	0.16
Port Stanley	May 15, 1970	Zn	52	129
		Hg	0.03	0.18
	June 7, 1971	Zn	39.2	102
UNITED STATES				
Barcelona	June 8, 1972	Zn	5.4	7.9
		Pb	1.7	4.3
		Hg	0.23	1.06
Dunkirk	June 8, 1972	Zn	11.4	12.2
		Pb	5.8	11.0
		Hg	0.58	1.48
Buffalo	June 20, 1972	Zn	19.0	26.2
		Pb	4.9	11.6
		Hg	0.60	3.9

TABLE 13

METAL CONCENTRATIONS IN SEDIMENTS
OF THE WESTERN BASIN OF
LAKE ERIE (MAY 1970)
CONCENTRATION (mg/kg)

METAL	MEAN	MINIMUM	MAXIMUM
Cadmium	5.6	2.2	13.7
Copper	79	30	183
Chromium	177	50	362
Zinc	224	54	530
Lead	86	30	173
Arsenic	7.9	4.0	12.3
Mercury	1.15	0.05	4.1

TABLE 14

VOLATILE ORGANICS (micrograms/litre)

City	$CHCI_3$	$BrCHCI_2$	Br_2CHCI	Br_3CH	CCl_4	CH_2CI_2	$C_2H_4Cl_2$
Detroit	5	6	2	0.3	1	0.5	1
Cleveland	10	5	0.7	<1	9	<1	<1
Toledo	62	20	4	<0.2	<0.5	<0.5	<1

LAKE ST. CLAIR

Chloride Concentration

The chloride parameter is a relatively conservative parameter which has been run on all major surveys on Lake St. Clair since 1947 and is generally considered a trace for pollutants in a body of water. At the levels found in Lake St. Clair, chloride data from older surveys can be compared with modern data with a reasonable degree of confidence.

The following general conclusions regarding long term changes in chloride concentrations in Lake St. Clair can be made:

1. Chloride concentrations in the shipping channel and on the American side of the lake, with the exception of L'Anse Creuse Bay, have not changed since 1947 and are very similar to St. Clair River water.
2. Chloride concentrations on the Canadian side of the lake were similar to the American side in 1947 but had approximately doubled by 1970 along the Canadian shore between Mitchell Bay and the Thames River. Furthermore, the increase in concentrations varies linearly with distance from the shipping channel.

Past Surveys - American (STORET)

An extensive water quality survey of Lake St. Clair was made during June thru November 1947. This survey covered 109 stations that were generally located on the IJC transects that have been established on the lake. Sampling frequency varied between 2 and 16 with an average of approximately 10 per station. Parameters included temperature, turbidity, dissolved oxygen, BOD, Ammonia, chloride and phenols. Some samples were also analyzed for chlorine demand, total solids and coliforms.

During 1964, another survey was made which covered 35 stations with 1 to 4 samples from each station. The stations were generally located on primary meridians and parallels that cross the lake. A large variety of parameters were measured including phosphorus and, at many stations, metals. Thirteen of these stations were reoccupied during 1967 and nine have been sampled periodically since then. Data from these surveys reflect a very complete range of parameters including radioactivity, metals and pesticides, but the largest number of samples accumulated at any station is 13 or 14.

Past Surveys - Canadian (MOE)

During 1967 the MOE initiated a series of sampling runs which involved a total of 108 different stations. These stations follow the IJC transects and are similar to the stations in the 1947 surveys. A large variety of parameters are measured. These surveys were repeated lakewide until 1970 so that 5 - 8 samples are available at every station. Subsequent to 1970, the program has been restricted to 12 stations located in the shipping channel. More than 26 runs have been made at these stations.

In addition, there is some isolated beach data and water intakes data in STORET from the Michigan DNR.

There have been several biological surveys of the lake which generally indicate a well balanced benthic population throughout the lake. This supports the thriving sports fishery that exists in the lake. Mean chloride concentrations from each survey were plotted along the IJC transects. This gives a good indication of how the chloride concentrations varied throughout the lake during each time period.

Results

The 1947 chloride concentrations were very constant throughout the lake, varying between 5.0 and 8.0 mg/l except at L'Anse Creuse Bay where concentrations were between 10 and 11 mg/l.

The 1964 American data and the Canadian data are in general agreement which indicated there is no systematic difference between American and Canadian chloride data.

The surveys show that there has been no significant change in chloride values in the main channel since 1947 and only a very slight increase on the American side of the lake. Concentrations at L'Anse Creuse Bay have increased to 12 - 13 mg/l. Concentrations in Anchor Bay range from 6.0 - 8.5 mg/l, which are similar to concentrations in the main channel. All other concentrations on the American side are below 10.0 mg/l except for one station very close to the shore (station 11). This higher value very close to shore (within 1/4 mile) was also reflected in the 1947 data.

There has been a substantial increase in chloride concentrations on the Canadian side of the channel. The increase is greater as the distance from the shipping channel increases and is greatest at Mitchell Bay and at the mouth of the Thames River with concentrations of 16 - 17 mg/l, or double the 1947 concentrations at those areas. The plots for transects 1-5-9, 3-4-8 and 13-6-7 (Figures 21, 22 and 23) show this gradient quite dramatically. The north-south transects show very little gradient indicating concentrations do not change from north to south in the lake.

The data available are not sufficient to determine if seasonal variations or patterns exist. No data are available for the months of December, January and February.

No reports on overall flow patterns within the lake were found. A flow pattern consistant with the chloride distribution and with the physical charcteristics of the lake can be postulated with a substantial degree of confidence, however, Figure 24 shows such a flow pattern which is dominated by the flow in the shipping channel. Major inputs come from the north and middle channels of the St. Clair River delta and sweep through Anchor Bay and southward along the American shore. The only area not directly in the path of this flow on the American side is L'Anse Creuse Bay where chloride concentrations are higher. The difference in chloride concentrations between point 100 (11.5 mg/l) which is west of Point Huron and out of the main flow and point 13 (7.4 mg/l) which is east of Point Huron and in the main flow is quite dramatic. This flow effectively sweeps the American side of the lake and prevents any build up of chlorides except at L'Anse Creuse Bay which is effected by the Clinton River cut off channel.

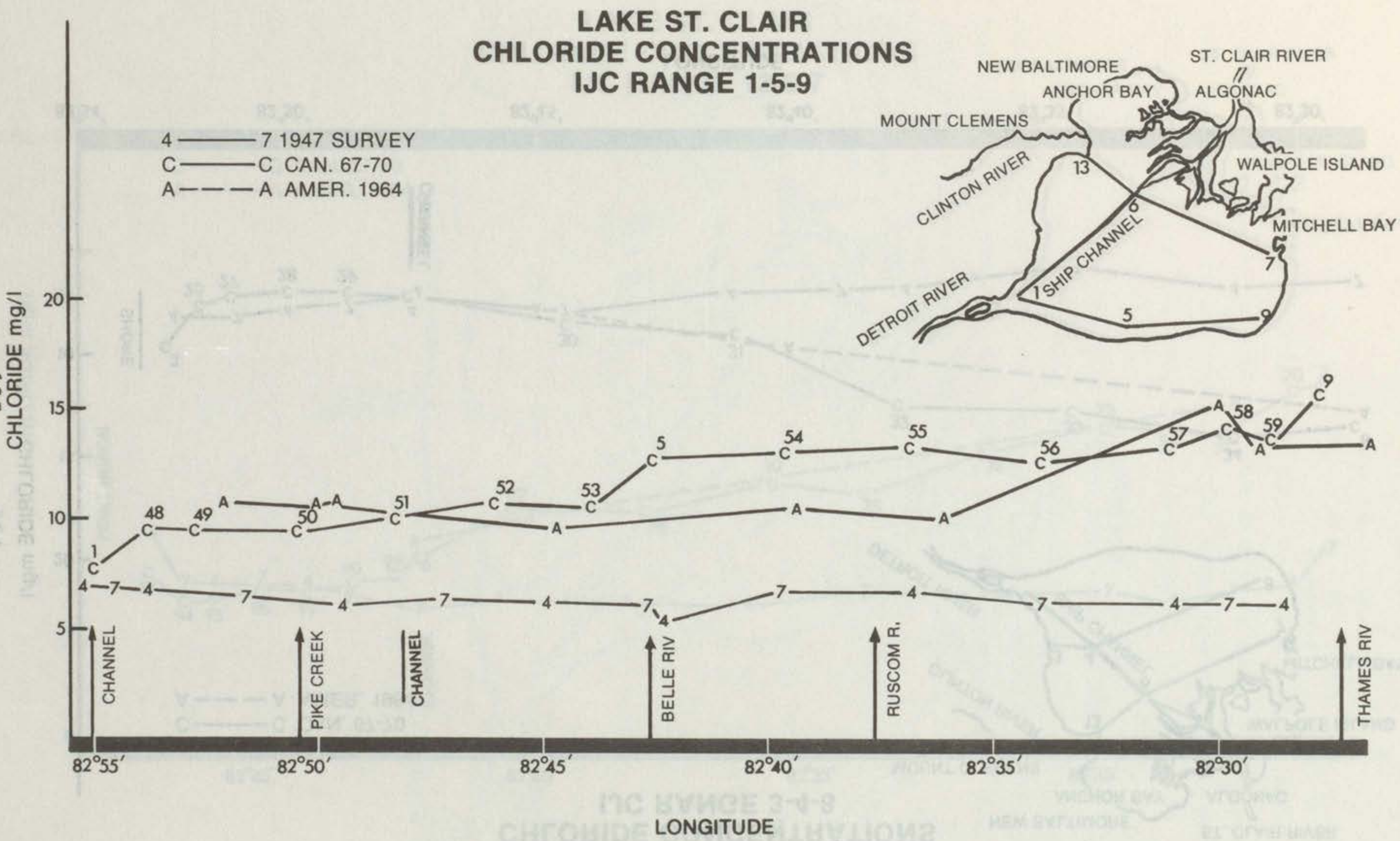

LAKE ST. CLAIR
CHLORIDE CONCENTRATIONS
IJC RANGE 1-5-9
4 —— 7 1947 SURVEY
C —— C CAN. 67-70
A – – – A AMER. 1964
CHLORIDE mg/l
20
15
10
5
CHANNEL
PIKE CREEK
CHANNEL
BELLE RIV
RUSCOM R.
THAMES RIV
82°55′
82°50′
82°45′
82°40′
82°35′
82°30′
LONGITUDE
NEW BALTIMORE
ANCHOR BAY
ST. CLAIR RIVER
ALGONAC
MOUNT CLEMENS
WALPOLE ISLAND
CLINTON RIVER
MITCHELL BAY
SHIP CHANNEL
DETROIT RIVER
1
5
6
7
9
13
48
49
50
51
52
53
54
55
56
57
58
59

FIGURE 21

LAKE ST. CLAIR
CHLORIDE CONCENTRATIONS
IJC RANGE 3-4-8

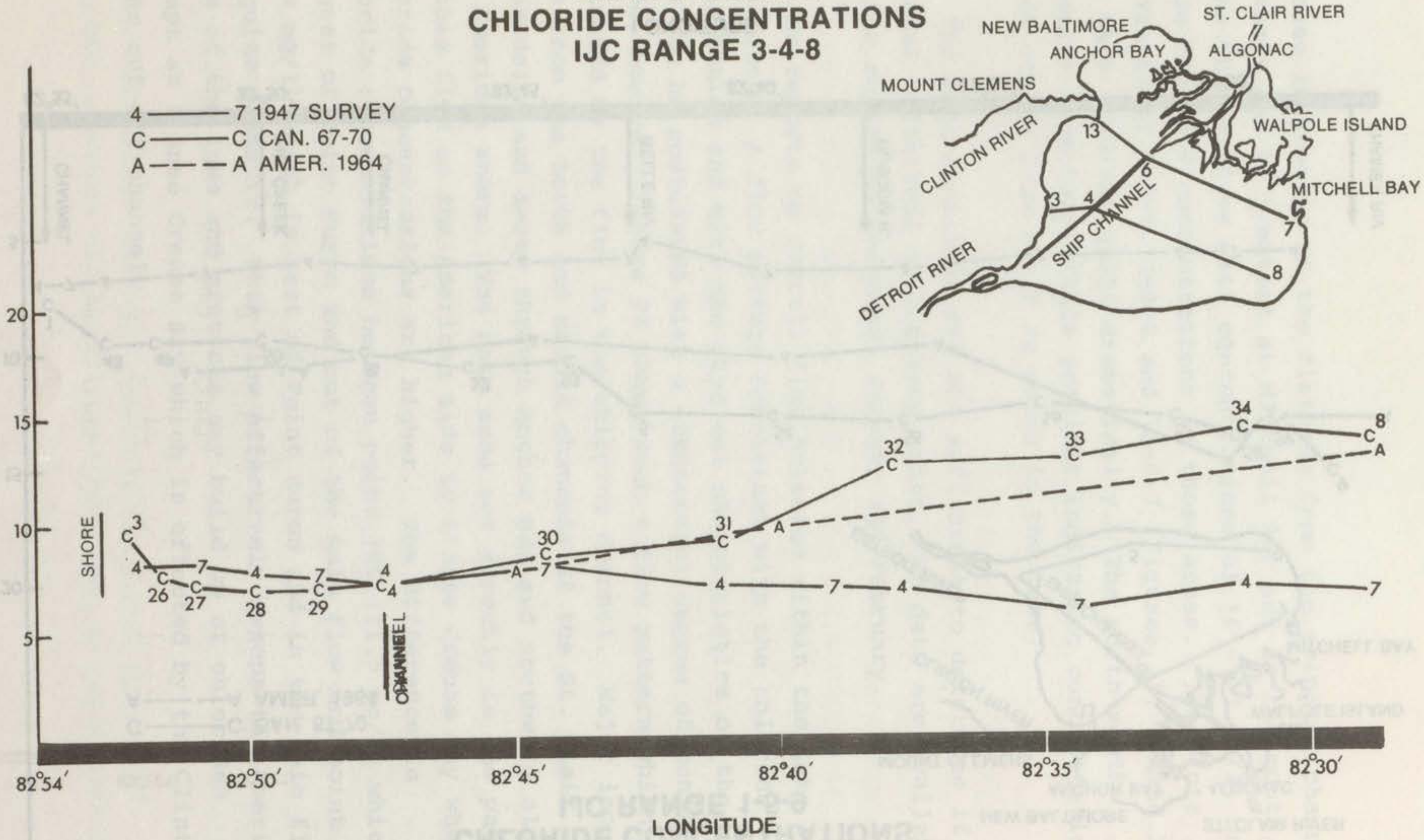


FIGURE 22

LAKE ST. CLAIR
CHLORIDE CONCENTRATIONS
IJC RANGE 13-6-7

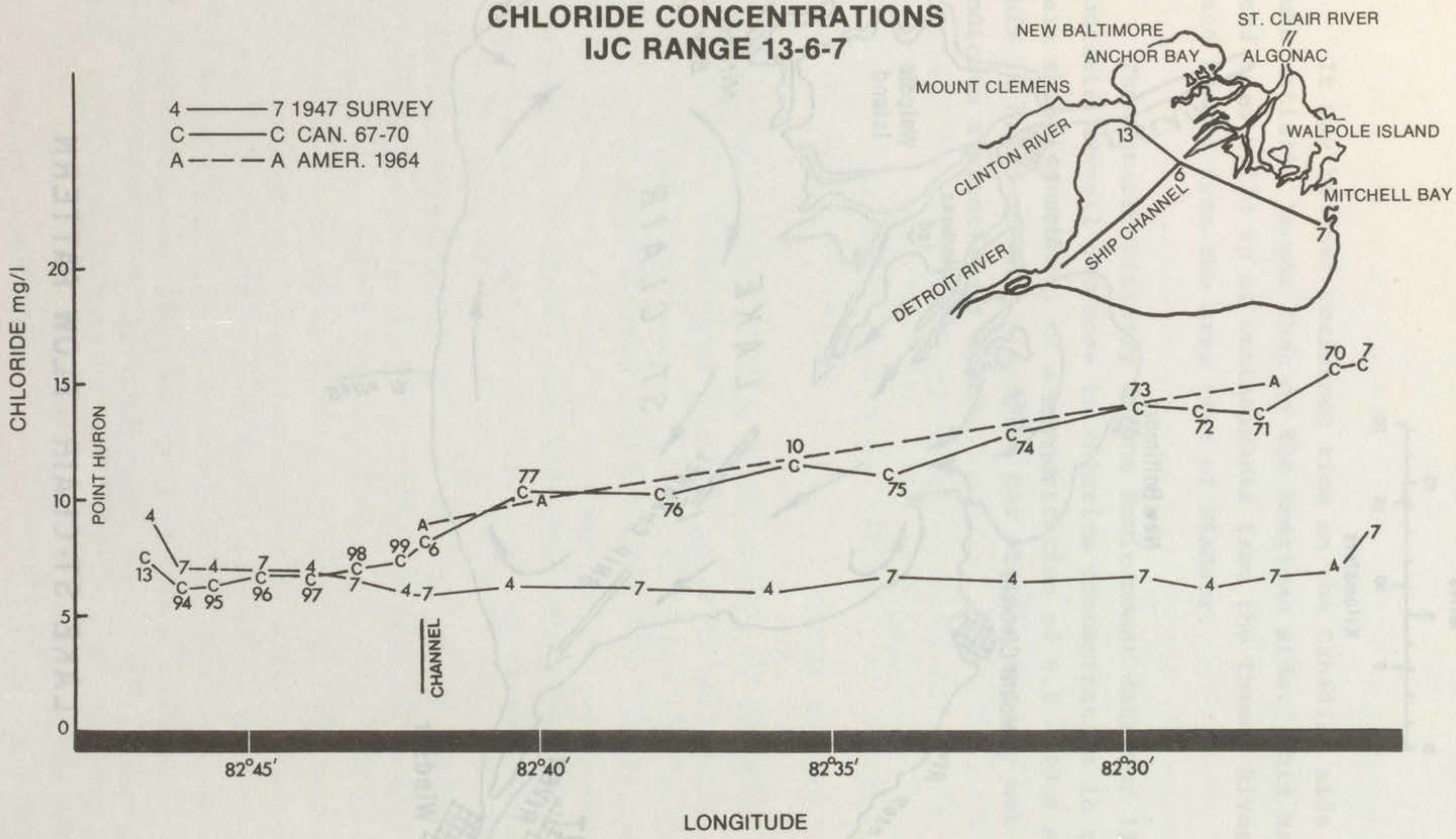
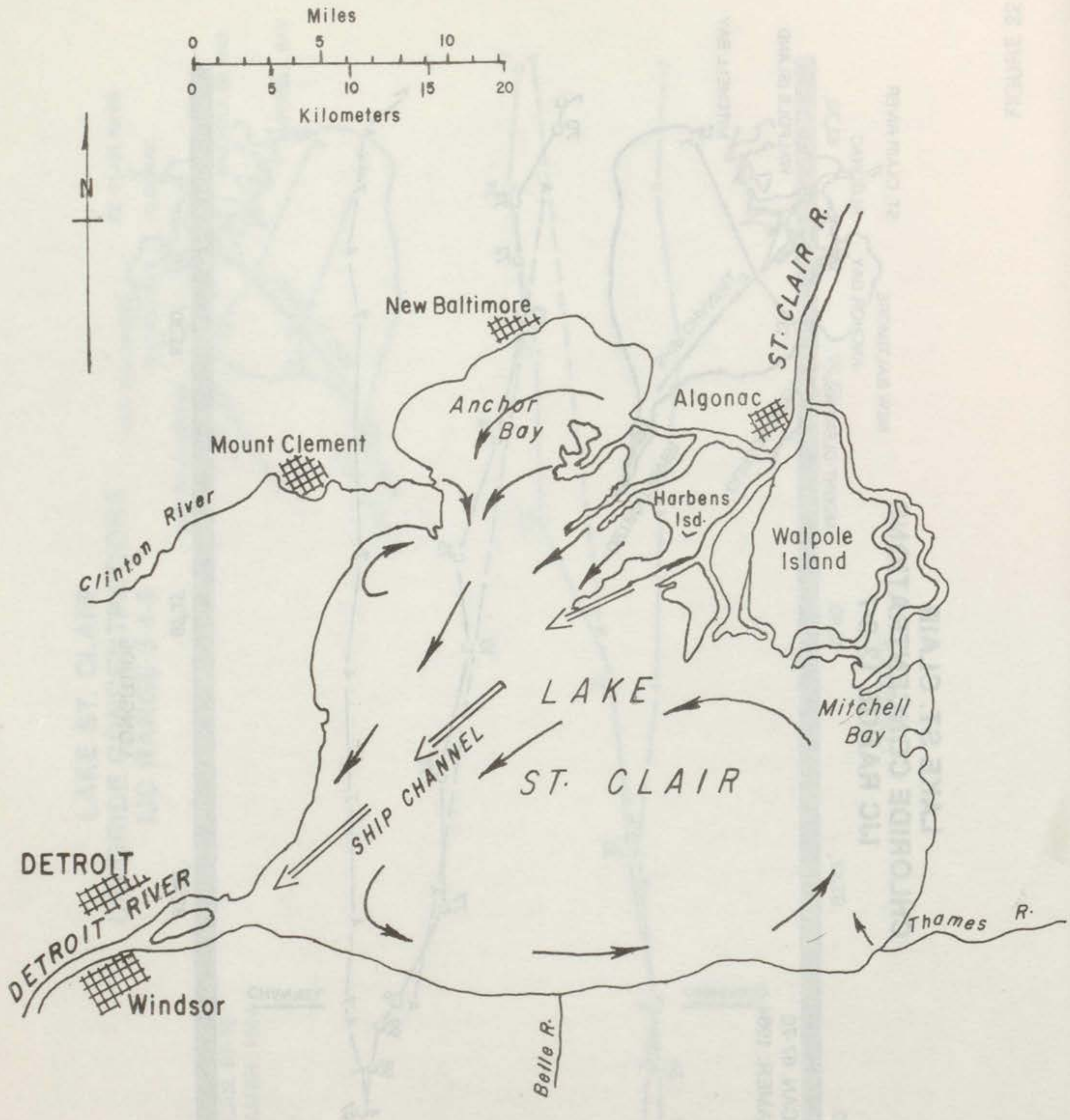


FIGURE 23



LAKE ST·CLAIR FLOW PATTERN

Figure 24

It may be that residence time on the Canadian side is substantially larger than on the American side. This has lead to a build up of contaminants from the Thames River and land runoff from the area east of Windsor.

The Ontario Ministry of the Environment data for 1974 indicate a small increase in chloride concentration in the main shipping channel to a concentration of 9.0 - 10.0 mg/l. This is based on only 4 samples per station and may not indicate a significant trend.

DETROIT RIVER

Details of Water Quality Surveillance Program

The Michigan Water Resources Commission conducted a water quality surveillance program of sampling the Detroit River during the open water periods (generally summer and fall). Approximately 59 stations were sampled for about 20 water quality parameters. The sampling frequency varied somewhat, but was generally about once per month. Sampling sites were arranged at several points across the river at a number of cross-sections, or "ranges", at measured distances from the river mouth.

Water Quality Trends

In order to examine water quality trends, results have been summarized at Range 3.9 (the cross-section 3.9 miles upstream from the river mouth), rather than throughout the entire river. This has been done because Range 3.9 is most representative of the combined effects of wastewater discharges in the Detroit-Windsor area. Also, it is the ideal cross-section to use in measuring the input to Lake Erie.

Tables 15 and 16 show the average concentrations and loadings of various materials in the river at Range 3.9 for each of the seven water years examined. The mean concentrations were developed by weighting individual concentrations across the range for flow to prepare Table 15. The weighting factors used were based on the percentange of river flow represented at each station on the range. Average annual flow rates were used with these weighted mean concentrations to prepare river loadings for Table 16.

Both loadings and concentrations should be considered in describing the water quality of a river such as the Detroit. This is because water quality changes may be caused by flow rate variations, and by changes in waste water inputs.

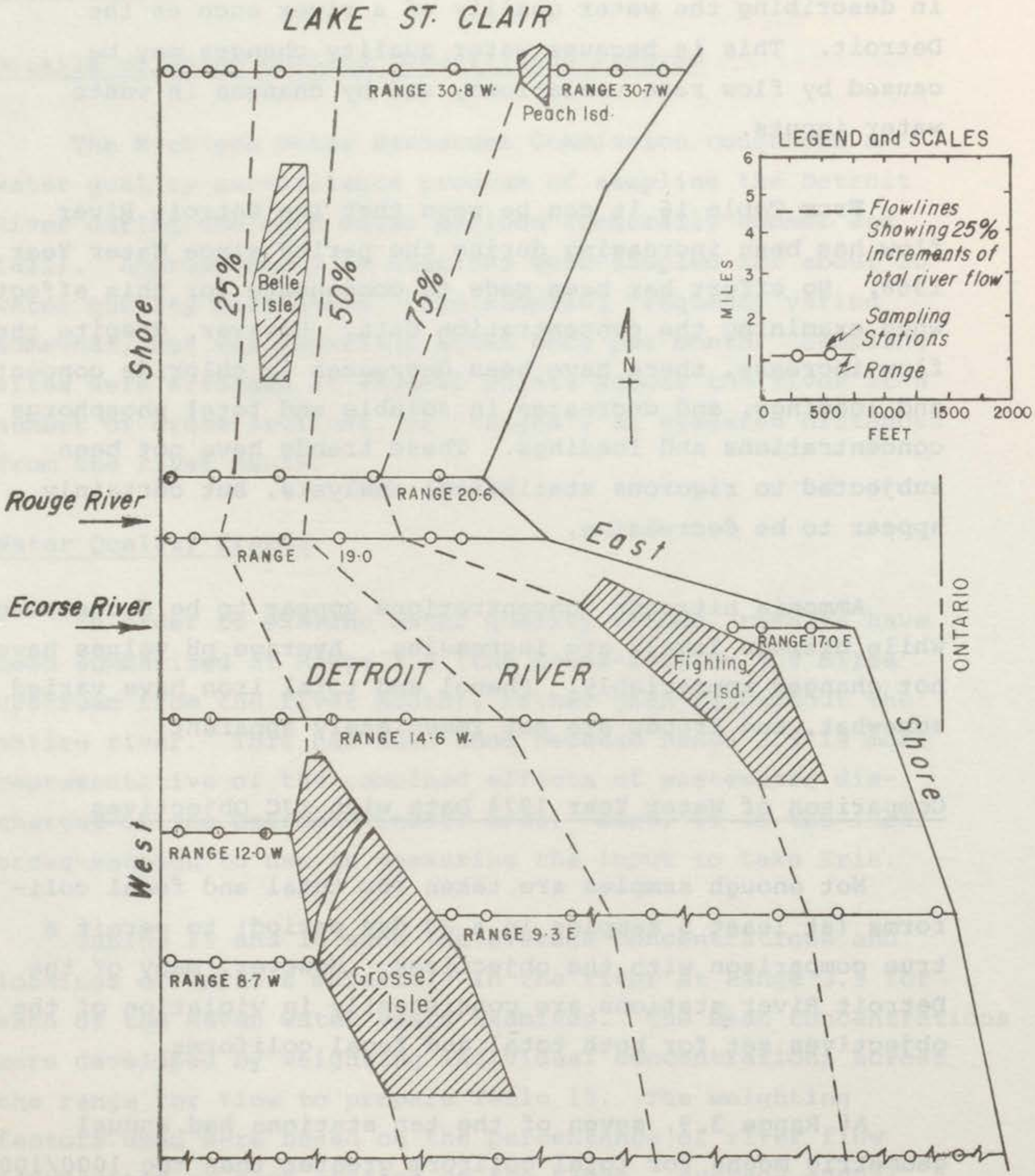
From Table 16 it can be seen that the Detroit River flow has been increasing during the period since Water Year 1968. No effort has been made to compensate for this effect when examining the concentration data. However, despite the flow increase, there have been decreases in chloride concentrations and loadings, and decreases in soluble and total phosphorus concentrations and loadings. These trends have not been subjected to rigorous statistical analysis, but certainly appear to be decreasing.

Ammonia nitrogen concentrations appear to be decreasing, while nitrate levels are increasing. Average pH values have not changed appreciably. Phenol and total iron have varied somewhat, and trends are not immediately apparent.

Comparison of Water Year 1974 Data with IJC Objectives

Not enough samples are taken for total and fecal coliforms (at least 5 samples in a 30 day period) to permit a true comparison with the objectives. However, many of the Detroit River stations are consistently in violation of the objectives set for both total and fecal coliforms.

At Range 3.9, seven of the ten stations had annual geometric means for total coliform greater than the 1000/100 ml objective. (Figure 25) Four stations had fecal coliform geometric means greater than the 200 counts/100 ml objective. Thus, difficulty in meeting the objectives is expected. The probable cause of the high counts is stormwater overflows from combined sewer systems.



STATIONS NOT IN COMPLIANCE WITH I·J·C OBJECTIVES
DETROIT RIVER RANGE DT3,9

Figure 25

None of the Detroit River stations experienced dissolved oxygen values below the 6.0 mg/l objective, and all mean values were well above this value. The lowest single value of dissolved oxygen at Range 3.9 was 6.2 mg/l.

Total dissolved solids at Range 3.9 averaged 178 mg/l for Water Year 1974. Therefore, the objective of a concentration in the Detroit River "consistent with maintaining the level of total dissolved solids in Lake Erie at not to exceed 200 milligrams per liter" was met.

Phenol was detectable at a number of locations in the river and at Range 3.9. Therefore, it was not "substantially absent" as the objective states.

Some individual pH values exceeded the maximum objective of 8.5, but all mean values were within the 6.7 to 8.5 range. Therefore the objective was generally met.

Total iron exceeded the 0.3 milligram per liter objective at many stations on the Detroit River and averaged 0.350 milligrams per liter at Range 3.9. Therefore, this objective was exceeded in many cases.

The continued reductions in phosphorus loadings to Lake Erie discussed above should help reduce "nuisance growths" of plant life in that lake.

Detroit River Loading Budget for 1974

The Detroit River Loading Budget is an attempt to use data from a number of monitoring programs to develop a materials balance for the Detroit River. Data from the Detroit River Monitoring Program, the Monthly River Monitoring

Program, the Detroit Industrial Monitoring Program and the Municipal Treatment Plant Operating Reports were used. In addition, the Industrial Surveillance Fee Program provided additional flow information where needed. The Ontario Water Resources Commission provided information on the Canadian contributions to the Detroit River.

The accompanying schematic diagram (Figure 26) indicates the input of municipal, industrial and tributary loading between the head and mouth of the Detroit River for six chemical parameters for 1974. The sum of these loadings is compared to the increase of these materials from the head to the mouth of the river and the total input accounted for is expressed as a percentage of that increase.

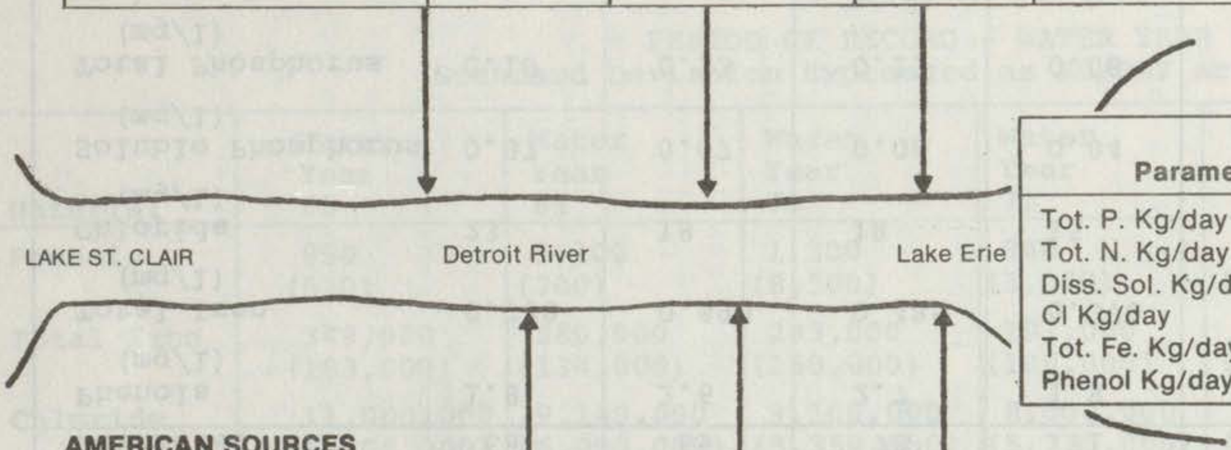
All entries in the schematic represent all the data currently available but not necessarily all the inputs to the river.

DETROIT RIVER LOADING BUDGET FOR WATER YEAR 1974

CANADIAN SOURCES

Parameter	Industrial	Municipal	Tributary[1]	Total
Tot. P. Kg/day	80	280	200	560
Tot. N. Kg/day	750	1,700	1,200	3,650
Diss. Sol. Kg/day	5,100,000	61,000	100,000	5,261,000
Cl Kg/day	3,000,000	15,000	24,000	3,039,000
Tot. Fe Kg/day	N.A.	N.A.	660	660
Phenol Kg/day	N.A.	N.A.	0	—
Flow Kl/sec.	3.9	1.5	N.A.	5.4

Detroit River Flow — 6,700 Kl/sec.



Parameter	Increase From Head to Mouth	Total Input Accounted For	%
Tot. P. Kg/day	12,000	16,710	140
Tot. N. Kg/day	136,000	10,850	8
Diss. Sol. Kg/day	13,200,000	7,435,000	56
Cl Kg/day	4,170,000	3,873,000	93
Tot. Fe. Kg/day	36,300	10,260	28
Phenol Kg/day	360	237	66

AMERICAN SOURCES

Parameter	Industrial	Municipal	Tributary	Total
Tot. P. Kg/day	250	15,000	900	16,150
Tot. N. Kg/day	N.A.	N.A.	7,200	7,200
Diss. Sol. Kg/day	370,000	504,000[2]	1,300,000	2,174,000
Cl Kg/day	170,000	504,000	160,000	834,000
Tot. Fe Kg/day	9,400	16,000	200	9,600
Phenol Kg/day	180	56	1	237
Flow Kl/sec.	115	29	38	182

[1] 1973 Data
[2] Chloride Portion of Dissolved Solids
N.A. — Data was not available

FIGURE 26

TABLE 15

Water Quality of Range DT 3.9 Located at the Mouth of the Detroit River

Data from the Detroit River Monitoring Program carried on by Michigan were used to prepare the table shown below. Approximately ten stations across the range were used in calculating the averages for each Water Year.

The mean concentrations were developed by weighting individual concentrations across the range for flow. The weighting factors used were based on the percentage of river flow represented at each station on the range.

Mean Daily Concentration-Water Year Basis

Parameter	Water Year 68	Water Year 69	Water Year 70	Water Year 71	Water Year 72	Water Year 73	Water Year 74
Phenols (mg/l)	1.8	2.6	2.7	1.8	1.7	1.4	2.2
Total Iron (mg/l)	0.730	0.590	0.485	0.370	0.580	0.390	0.350
Chloride (mg/l)	23	18	18	15	17	14	16
Soluble Phosphorus (mg/l)	0.07	0.07	0.08	0.04	0.03	0.02	0.02
Total Phosphorus (mg/l)	0.18	0.13	0.13	0.08	0.07	0.08	0.05
Ammonia Nitrogen (mg/l)	0.12	0.13	0.14	0.16	0.15	0.10	0.13
Nitrate Nitrogen (mg/l)	0.19	0.17	0.27	0.28	0.32	0.25	0.27
pH	7.9	7.9	8.0	8.1	7.9	7.9	8.0
Dissolved Oxygen (mg/l)	8.1	8.6	7.7	7.8	9.1	7.9	8.9

TABLE 16

Detroit River Loadings to Lake Erie

Data from the Detroit River Monitoring Program carried on by Michigan were used to prepare the table shown below. The table shows the mean daily river loadings of seven water quality parameters at 3.9 miles upstream from the river mouth. Approximately ten stations across the river at this point were used to calculate the loadings, which represent the amounts of the various materials entering Lake Erie. The average measured concentrations were multiplied by the average annual flow rates to obtain the loadings.

Mean Daily Loadings as KG/DAY Passing Range DT 3.9 at the Mouth of the Detroit River

PERIOD OF RECORD - WATER YEAR BASIS
Standard Deviation Expressed as KG/DAY are in parenthesis

Material	Water Year 68	Water Year 69	Water Year 70	Water Year 71	Water Year 72	Water Year 73	Water Year 74
Phenols	850 (520)	1,100 (700)	1,300 (8,500)	940 (1,050)	910 (1,450)	800 (1,100)	1,300 (1,500)
Total Iron	349,000 (183,000)	280,000 (134,000)	243,000 (150,000)	197,000 (106,000)	310,000 (272,000)	230,000 (130,000)	200,000 (100,000)
Chloride	11,000,000 (6,800,000)	9,140,000 (6,000,000)	9,100,000 (5,350,000)	8,000,000 (5,770,000)	9,000,000 (5,450,000)	8,200,000 (5,010,000)	9,400,000 (4,630,000)
Soluble Phosphorus	32,000 (61,000)	39,000 (71,000)	39,000 (65,000)	19,000 (21,700)	18,000 (21,600)	12,000 (10,400)	13,000 (13,900)
Total Phosphorus	87,000 (76,000)	68,000 (83,000)	65,000 (62,000)	41,000 (41,800)	40,000 (38,300)	44,000 (24,200)	30,000 (28,900)
Ammonia Nitrogen	58,000 (78,000)	65,000 (97,000)	71,000 (98,000)	85,000 (111,000)	84,000 (91,200)	60,000 (77,800)	72,000 (87,900)
Nitrate Nitrogen	89,000 (37,000)	86,000 (61,000)	138,000 (102,000)	147,000 (162,000)	173,000 (146,000)	146,000 (90,400)	157,000 (64,800)
Flow	5,500	5,900	5,800	6,200	6,200	6,700	6,700

ST. CLAIR RIVER

Water Quality Conditions and Areas of Non-compliance

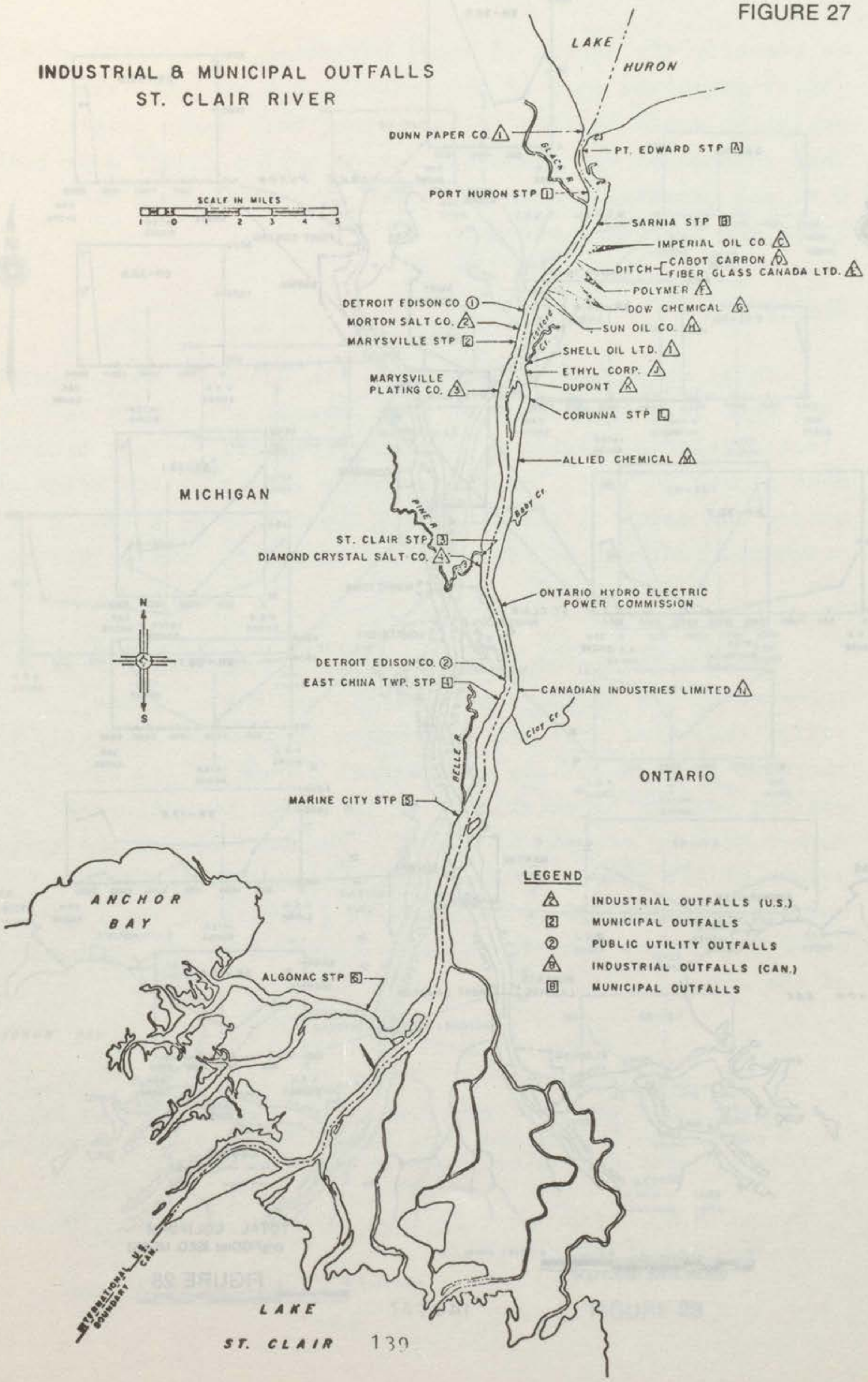
The St.Clair River connects Lake Huron on the north with Lake St. Clair, the Detroit River and Lake Erie on the south. Effluents entering the river from both the Canadian and U.S. shores are shown in Figure 27. Mean concentrations from the 1974 surveys were plotted against those of 1968 to provide a visual comparison of changing water quality status. Trend analyses were performed to examine the rate of change in water quality at selected points in the river.

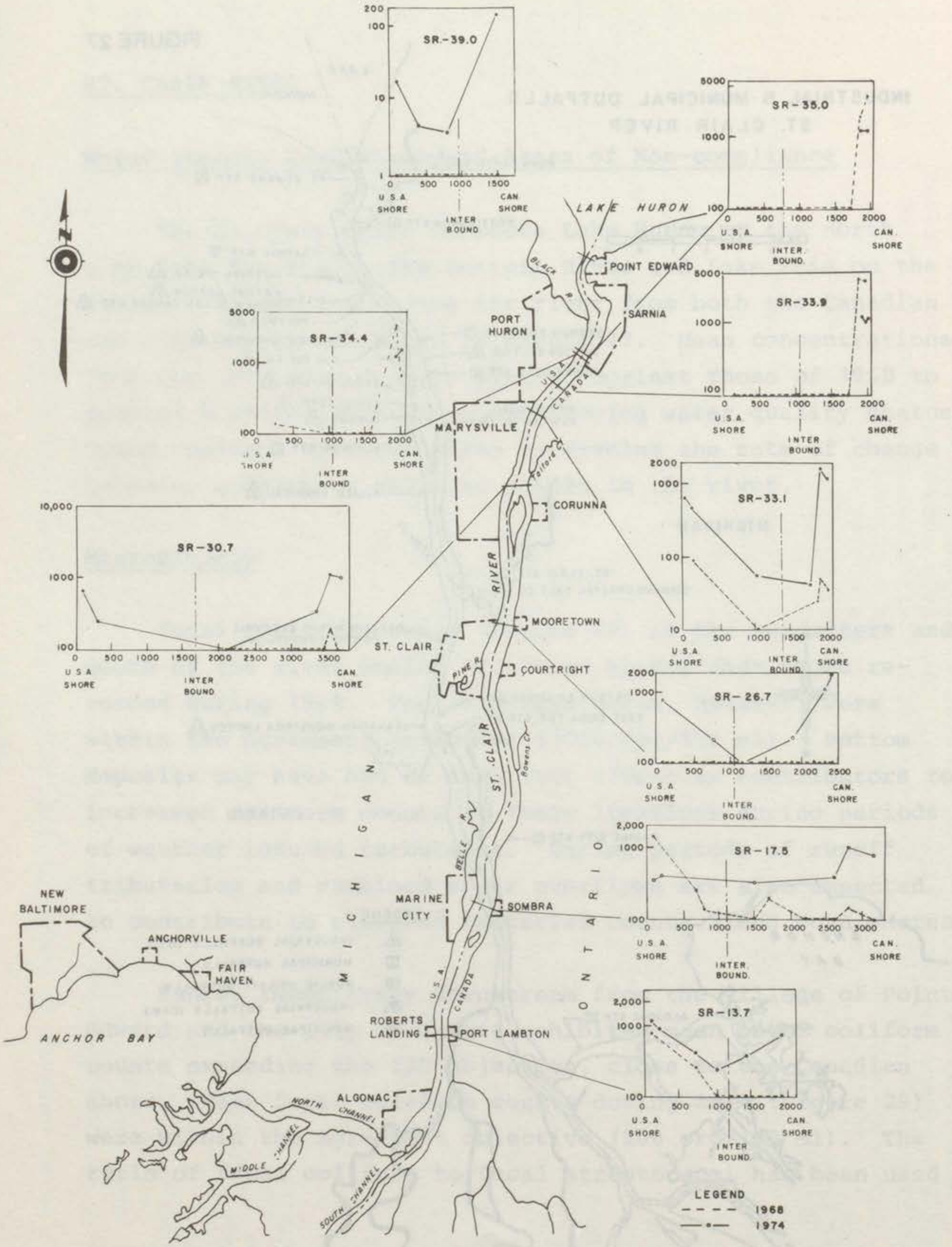
Microbiology

Total coliform counts (Figure 28) at the headwaters and mouth of the river during 1974 were higher than those recorded during 1968. The geometric means, however, were within the Agreement objective (1000 org/100 ml). Bottom deposits may have had an important effect as contributors to increased coliform counts at these locations during periods of weather induced turbulence. During periods of runoff tributaries and combined sewer overflows are also expected to contribute to elevated bacterial counts along both shores.

Ranges immediately downstream from the village of Point Edward and the City of Sarnia exhibited mean total coliform counts exceeding the IJC objective, close to the Canadian shore. Mean fecal coliform counts during 1974 (Figure 29) were within the Agreement objective (200 org/100 ml). The ratio of fecal coliform to fecal streptococci has been used

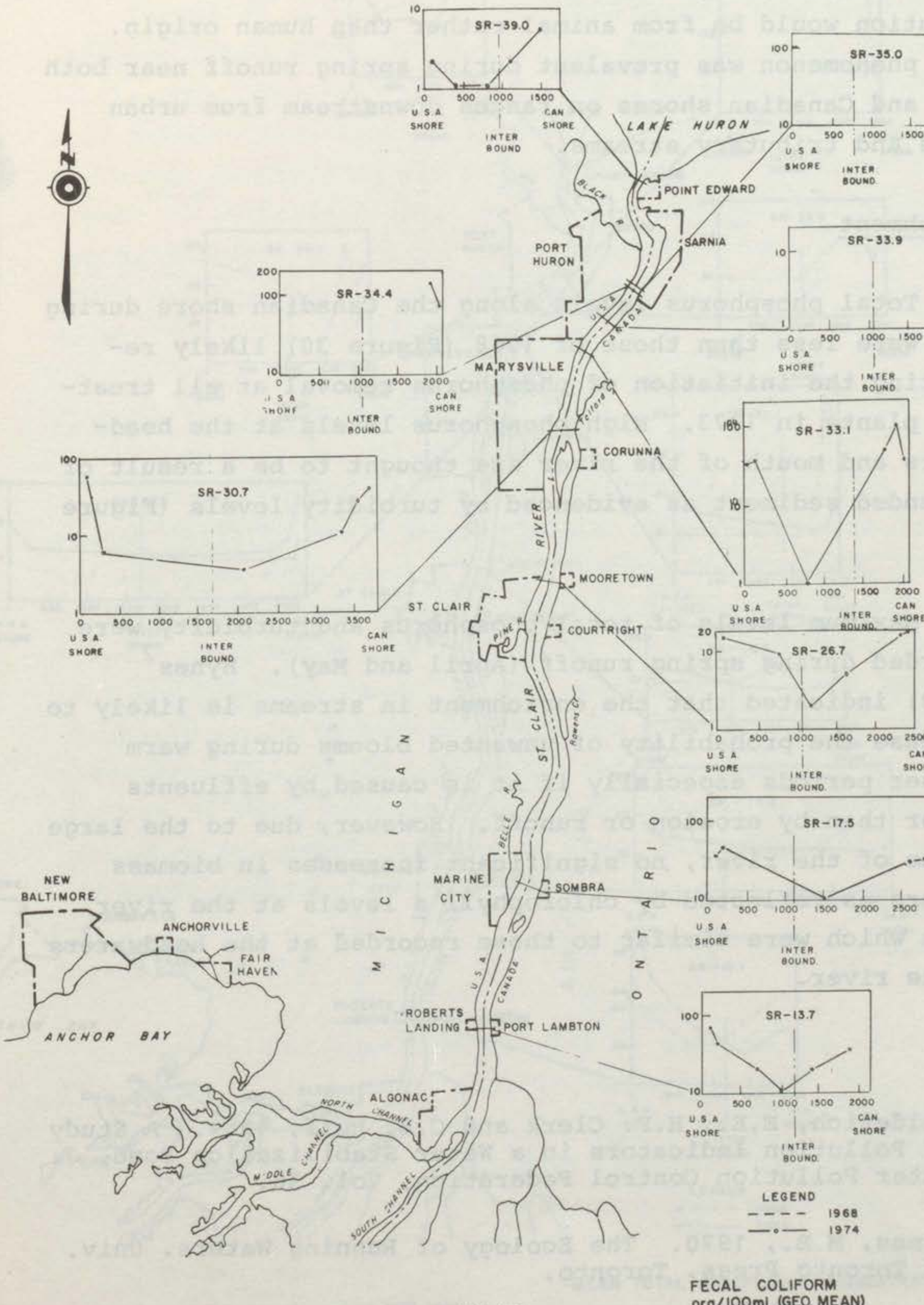
FIGURE 27


INDUSTRIAL & MUNICIPAL OUTFALLS
ST. CLAIR RIVER
SCALE IN MILES
1 0 1 2 3 4 5
LAKE
HURON
DUNN PAPER CO.
PT. EDWARD STP
BLACK R.
PORT HURON STP
SARNIA STP
IMPERIAL OIL CO
DITCH
CABOT CARBON
FIBER GLASS CANADA LTD.
POLYMER
DETROIT EDISON CO
MORTON SALT CO.
MARYSVILLE STP
DOW CHEMICAL
SUN OIL CO.
SHELL OIL LTD.
ETHYL CORP.
MARYSVILLE
PLATING CO.
DUPONT
CORUNNA STP
ALLIED CHEMICAL
MICHIGAN
PINE R.
Baby Cr.
ST. CLAIR STP
DIAMOND CRYSTAL SALT CO.
ONTARIO HYDRO ELECTRIC
POWER COMMISSION
N
S
DETROIT EDISON CO.
EAST CHINA TWP. STP
CANADIAN INDUSTRIES LIMITED
Clay Cr.
BELLE R.
ONTARIO
MARINE CITY STP
ANCHOR
BAY
LEGEND
INDUSTRIAL OUTFALLS (U.S.)
MUNICIPAL OUTFALLS
PUBLIC UTILITY OUTFALLS
INDUSTRIAL OUTFALLS (CAN.)
MUNICIPAL OUTFALLS
ALGONAC STP
INTERNATIONAL BOUNDARY
U.S.
CAN.
LAKE
ST. CLAIR



TOTAL COLIFORM
org/100ml (GEO. MEAN)

FIGURE 28



FECAL COLIFORM
org/100ml (GEO. MEAN)

FIGURE 29

to identify the source of fecal pollution. Gelderich et al[1] (1964) suggested that if the ratio is 0.7 or less, the pollution would be from animal rather than human origin. This phenomenon was prevalent during spring runoff near both U.S. and Canadian shores on ranges downstream from urban areas and tributary streams.

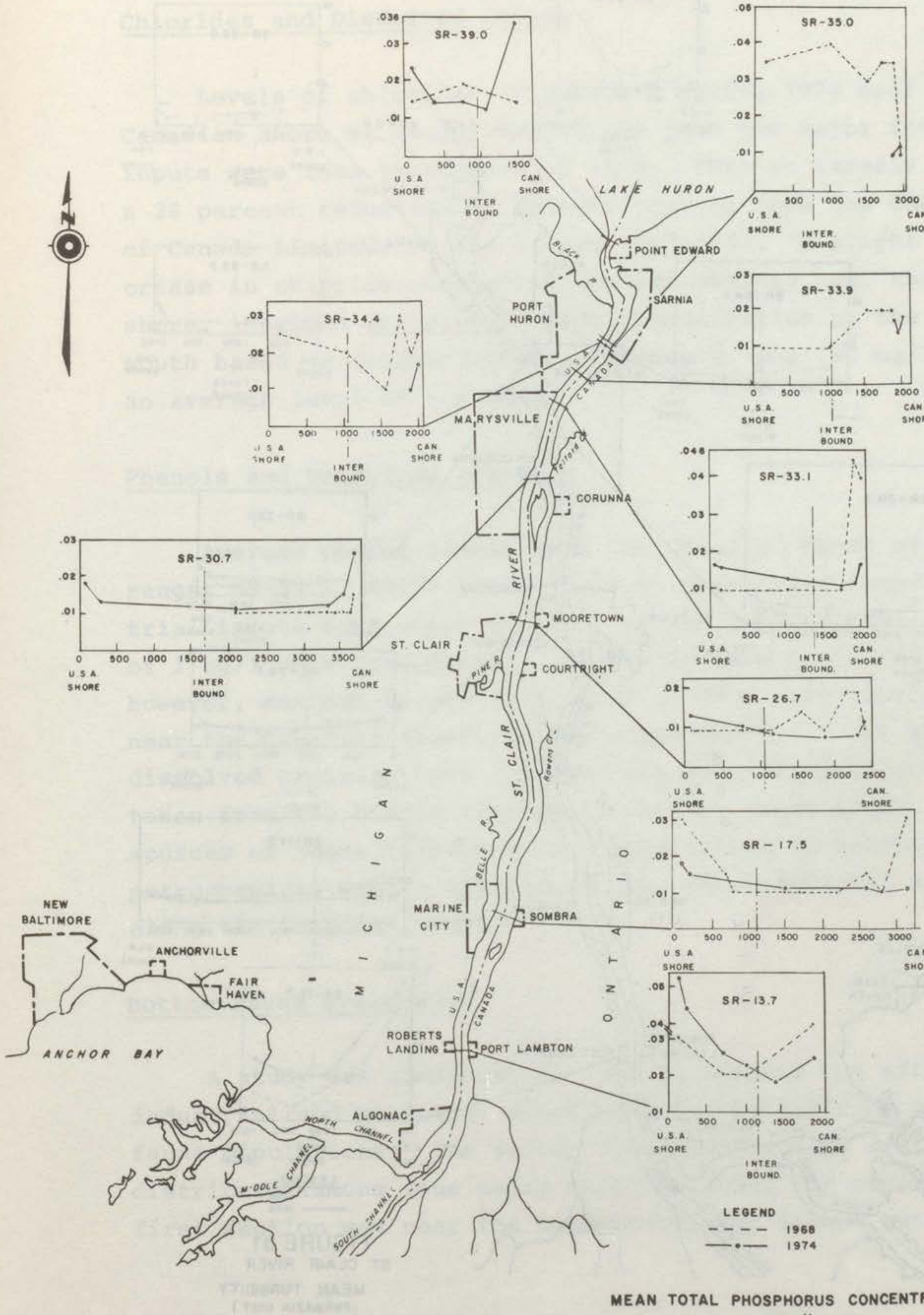
Enrichment

Total phosphorus levels along the Canadian shore during 1974 were less than those of 1968 (Figure 30) likely reflecting the initiation of phosphorus removal at all treatment plants in 1973. High phosphorus levels at the headwaters and mouth of the river are thought to be a result of suspended sediment as evidenced by turbidity levels (Figure 31).

Maximum levels of total phosphorus and turbidity were recorded during spring runoff (April and May). Hynes[2] (1970) indicated that the enrichment in streams is likely to increase the probability of unwanted blooms during warm weather periods especially if it is caused by effluents rather than by erosion or runoff. However, due to the large volume of the river, no significant increases in biomass occcurs as reflected by chlorophyll a levels at the river mouth which were similar to those recorded at the headwaters of the river.

[1] Gelderich, E.E., H.F. Clerk and C.B. Huff, 1964. A Study of Pollution Indicators in a Water Stabilization Pond. J. Water Pollution Control Federation, Vol. 36.

[2] Hynes, M.B., 1970. The Ecology of Running Waters. Univ. of Toronto Press, Toronto.



MEAN TOTAL PHOSPHORUS CONCENTRATIONS
mg/l

FIGURE 30

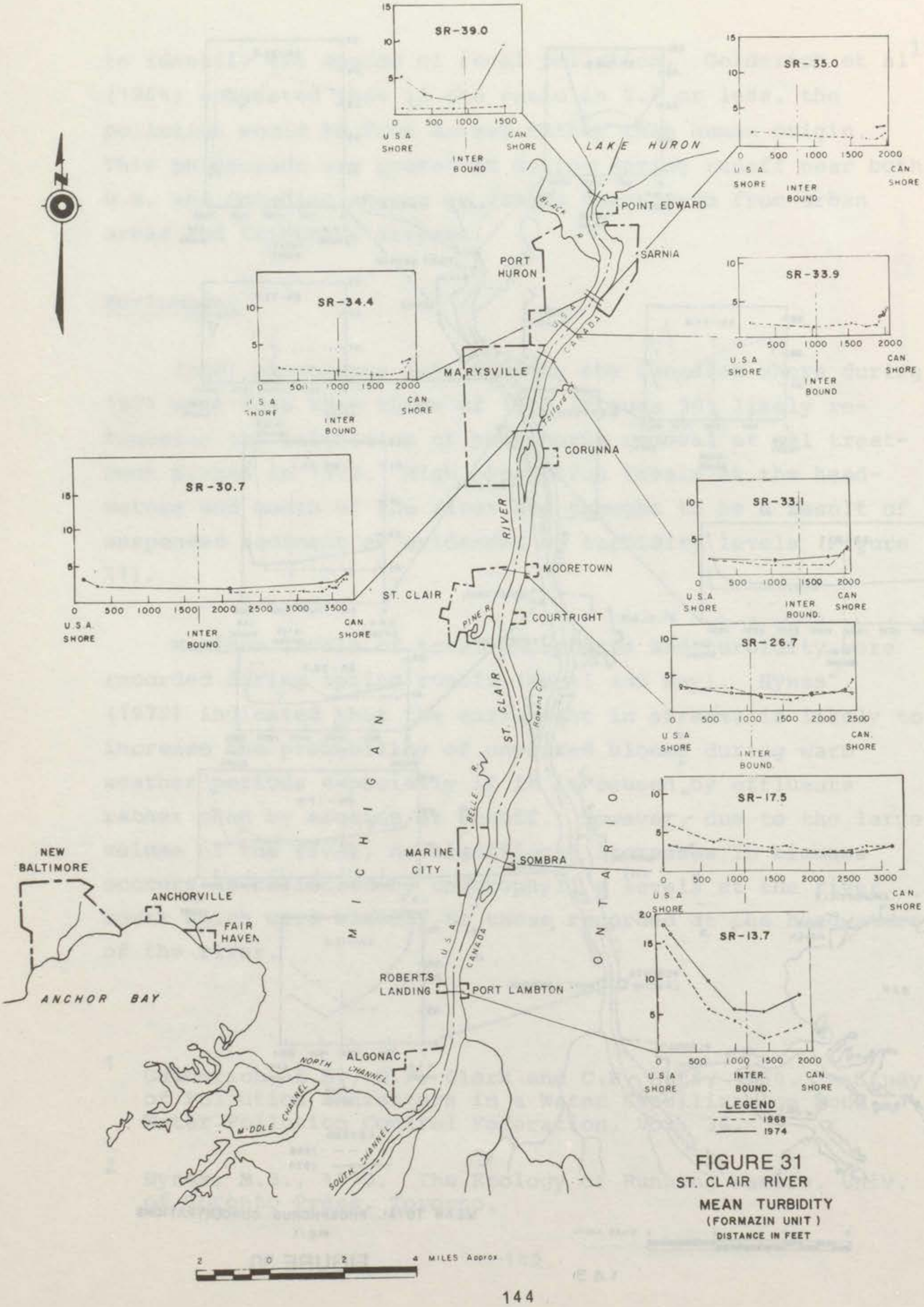


FIGURE 31
ST. CLAIR RIVER
MEAN TURBIDITY
(FORMAZIN UNIT)
DISTANCE IN FEET

Chlorides and Dissolved Solids

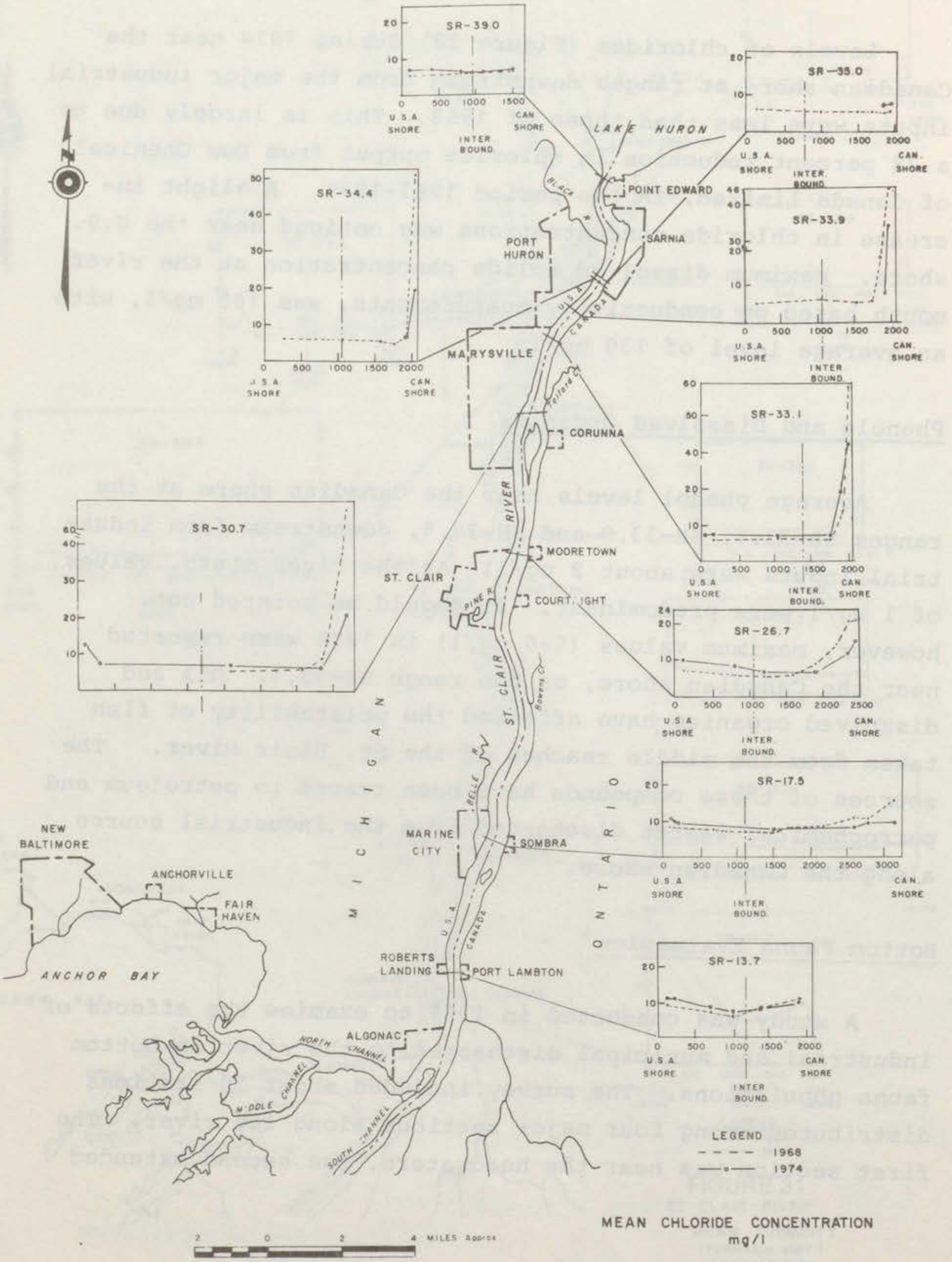
Levels of chlorides (Figure 32) during 1974 near the Canadian shore at ranges downstream from the major industrial inputs were less than those of 1968. This is largely due to a 38 percent reduction in chloride output from Dow Chemical of Canada Limited, in the period 1967-1974. A slight increase in chloride concentrations was noticed near the U.S. shore. Maximum dissolved solids concentration at the river mouth based on conductivity measurements, was 160 mg/l, with an average level of 130 mg/l.

Phenols and Dissolved Organics

Average phenol levels near the Canadian shore at the ranges SR-33.1, SR-33.9 and SR-34.4, downstream from industrial inputs were about 2 ug/l. At the river mouth, values of 1 ug/l were predominant. It should be pointed out, however, maximum values (5-6 ug/l) in 1974 were reported near the Canadian shore, on the range SR-33.1. Oil and dissolved organics have affected the palatability of fish taken from the middle reaches of the St. Clair River. The sources of these compounds have been traced to petroleum and petrochemical wastes discharged from the industrial source along the Canadian shore.

Bottom Fauna Evaluation

A study was conducted in 1969 to examine the effects of industrial and municipal discharges to the river on bottom fauna populations. The survey included about 70 stations distributed among four major sections along the river. The first section was near the headwaters, the second extended



MEAN CHLORIDE CONCENTRATION
mg/l

FIGURE 32

to the south of Stag Island, including most of the industrial inputs. The third section extended to the Detroit Edison Company plant, north of Marine City and the remaining area included the river mouth.

The study indicated the benthic macroinvertebrate community in the upper reaches of the river was diverse and typical of good water quality along both of the U.S. and Canadian shores. The average number of taxa per station along the U.S. shore from the headwaters to Marine City remained roughly unaltered and was similar to the background levels. However, along the Canadian shore, the variety of organisms was significantly reduced from an average of 12.3 taxa/station (at headwaters) to 4.6 taxa/station in the second section indicating a significant impact of industrial discharges on the bottom fauna habitat.

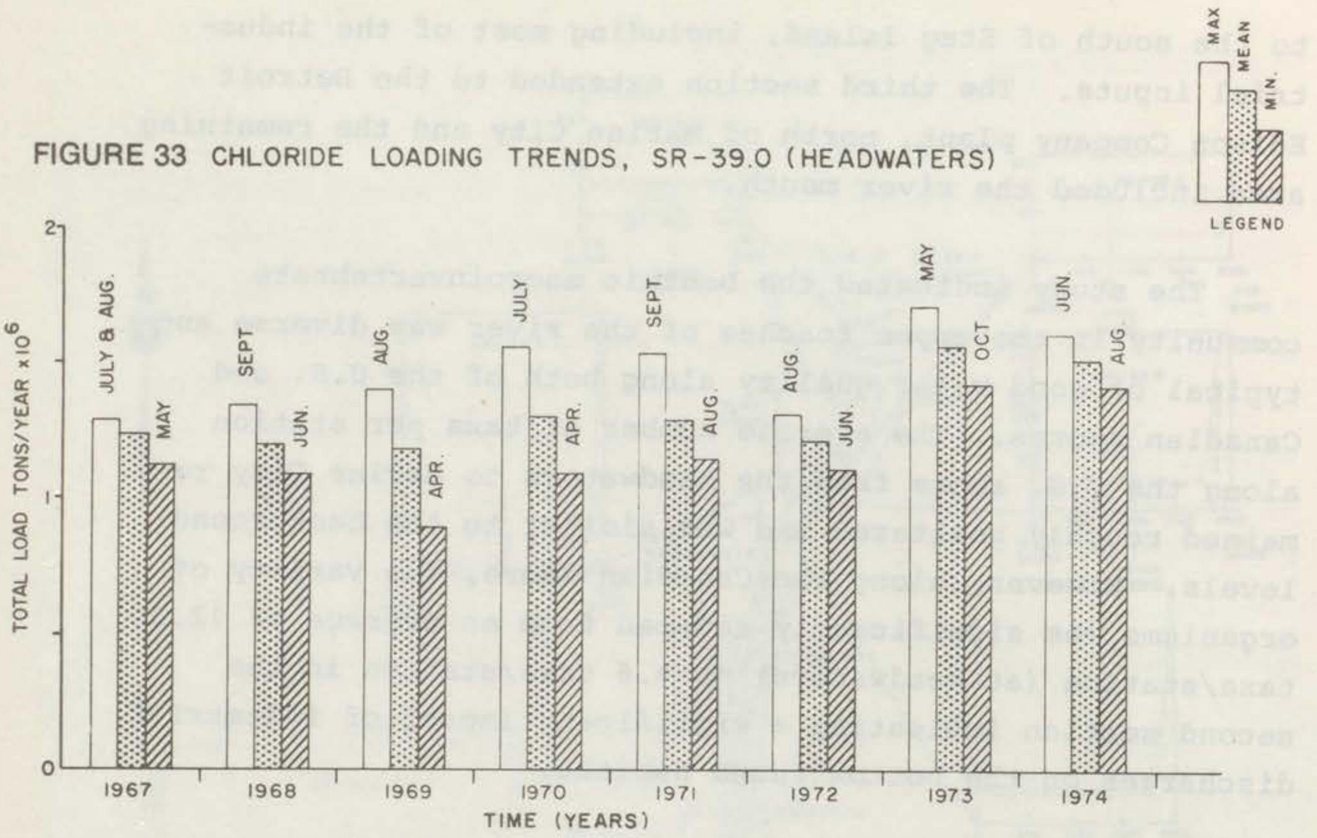
A limited increase in variety and significant increases in average bottom fauna numbers per square meter, downstream from Stag Island revealed the occurrence of organic decomposition in the last two reaches. Bottom fauna associations did not recover to the background level or to those observed along the adjacent U.S. shore.

Trend Analyses

Range SR39.0 (Headwaters)

Chloride loadings at the headwaters of the river (Figure 33) exhibited an increasing trend during the period 1967-74. This increase is related to the increase in the river flow (Figure 34) and an unexplained increase in chloride concentration near the U.S. shore. The mean annual flow has increased approximately 6000 cfs/year (significant at 95

FIGURE 33 CHLORIDE LOADING TRENDS, SR-39.0 (HEADWATERS)



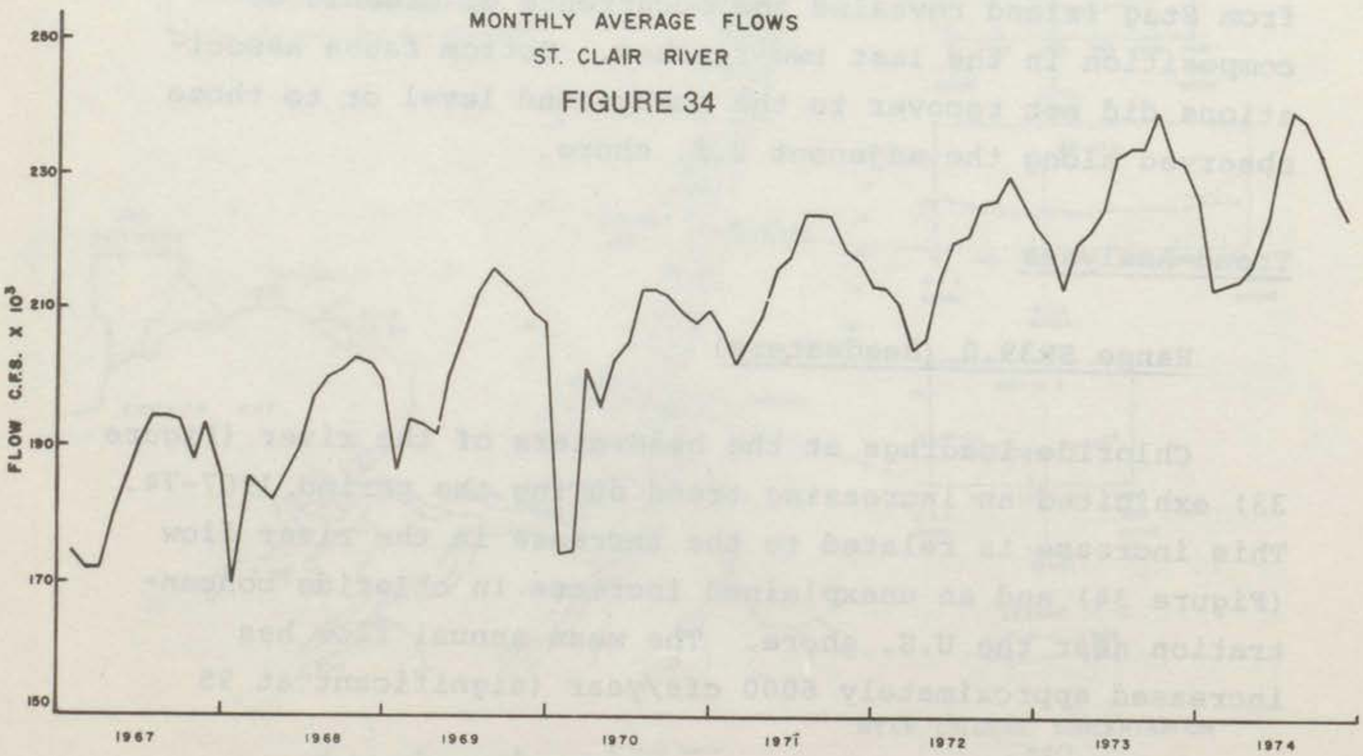


FIGURE 34

percent confidence level with a correlation coefficient of 0.98). Mean phosphorus loadings (Figure 35) were almost identical from 1968-1974 in spite of the flow increase.

Range SR35.0 (Downstream from Sarnia)

Total phosphorus levels near the Canadian shore indicated a downward trend (Figure 36). Levels in 1968 were about 6 ug/l higher than those recorded in 1973 and 1974.

Range SR33.9 (Downstream from Dow Chemical of Canada Ltd.)

Mean chloride levels (Figure 37) near the Canadian shore exhibited a significant downward trend (at 95 percent confidence level). Chlorides were about 15 mg/l higher in 1968 than in 1973 and 1974, indicating an appreciable decrease in chloride outputs from Dow Chemical of Canada Ltd.

Range SR17.5

Chloride levels near the Canadian shore exhibited a pattern similar to those observed in the upper ranges. However, at the U.S. shore, chlorides were about 4 mg/l higher in 1973 and 1974 than in 1967 and 1968 (Figure 38) increasing at a rate of 0.5 mg/l per year (at 95 percent confidence level).

Range SR13.7 (River Mouth)

Chloride and phosphorus loadings (Figures 39 and 40) exhibited patterns similar to those observed at the headwaters, i.e. increase in chloride loadings and no significant changes in phosphorus loadings. Chloride concentrations at the Canadian shore (Figure 41) revealed a downward trend

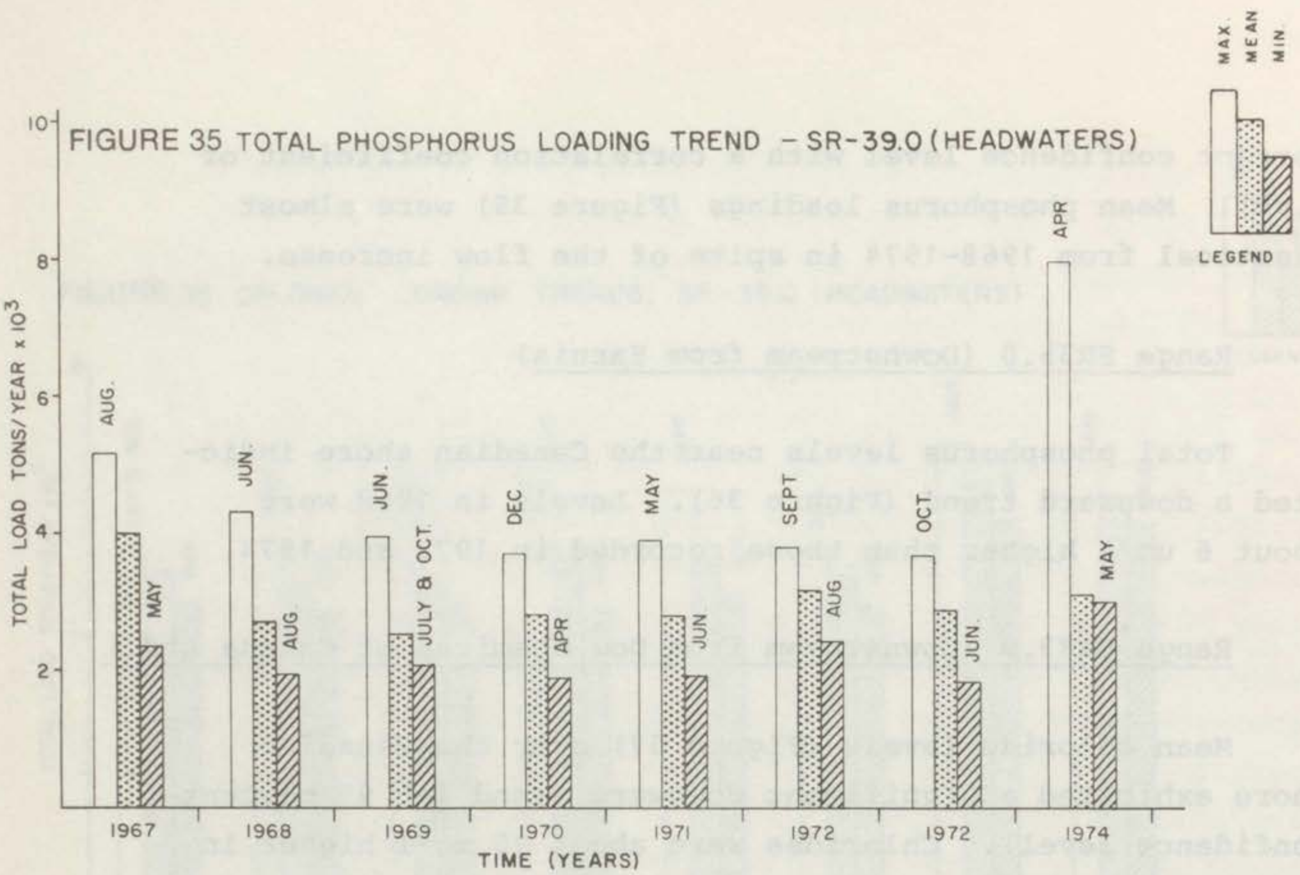


FIGURE 35 TOTAL PHOSPHORUS LOADING TREND – SR-39.0 (HEADWATERS)

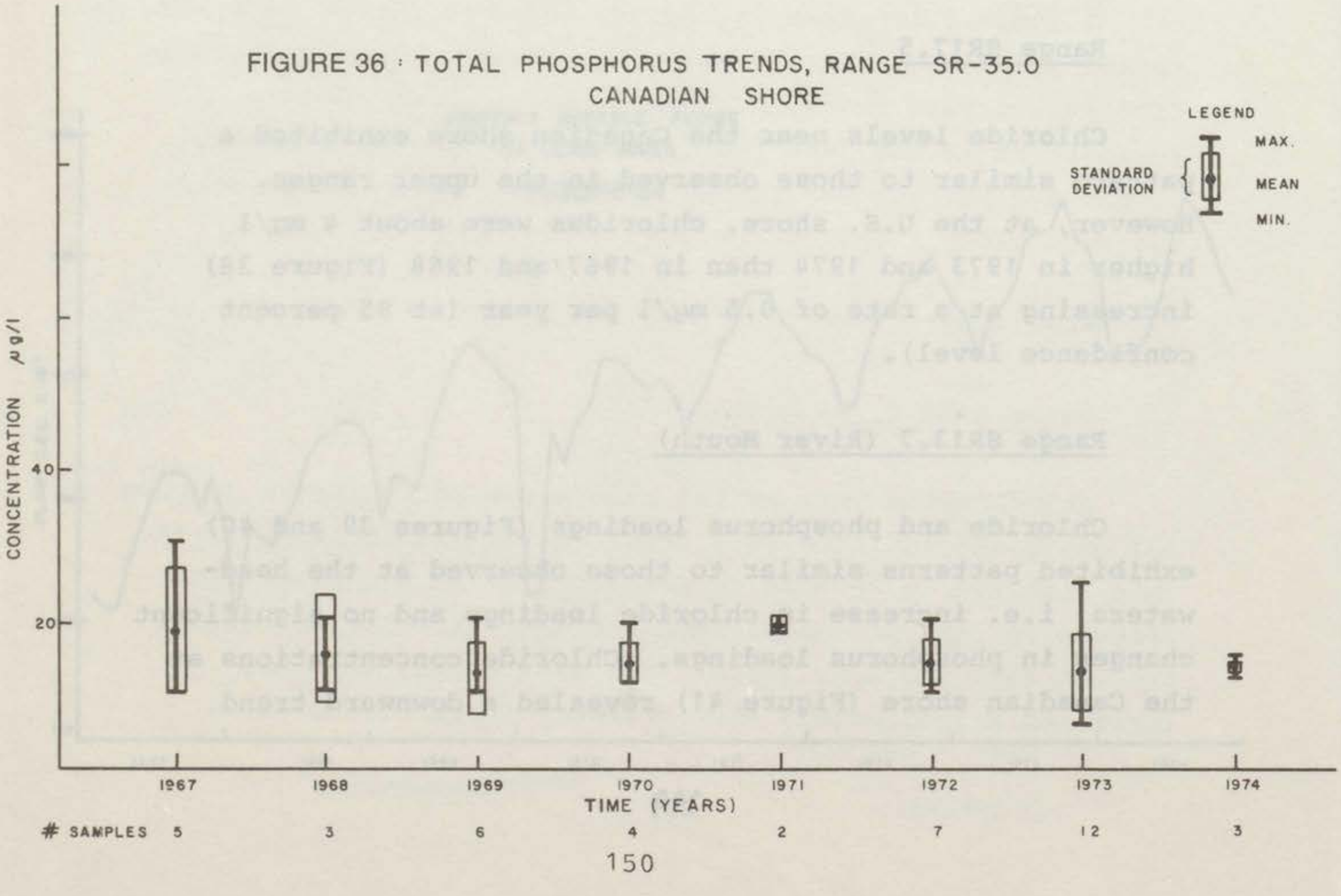
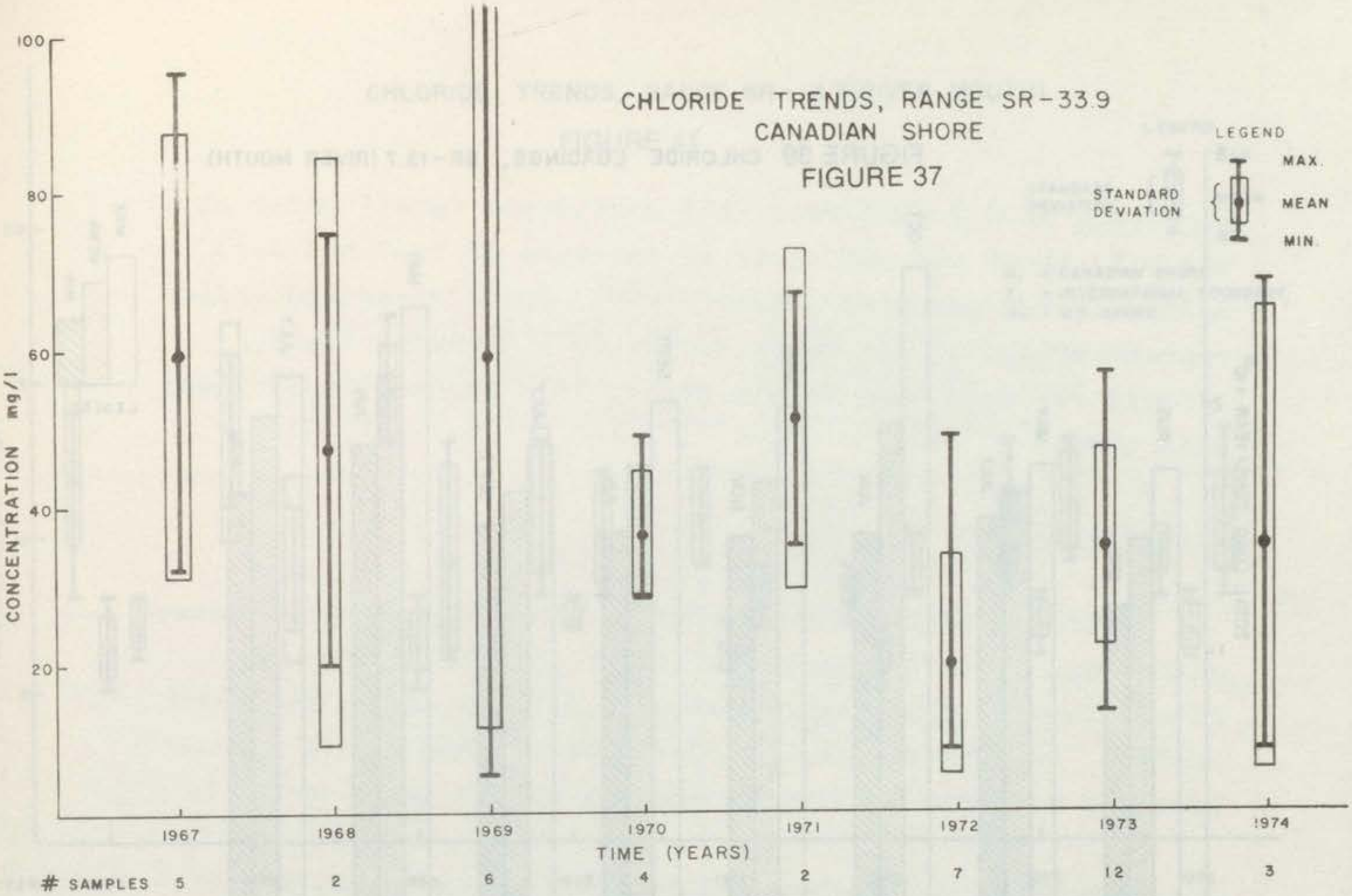


FIGURE 36 : TOTAL PHOSPHORUS TRENDS, RANGE SR-35.0 CANADIAN SHORE


CHLORIDE TRENDS, RANGE SR-33.9
CANADIAN SHORE
FIGURE 37
LEGEND
STANDARD DEVIATION
MAX.
MEAN
MIN.
CONCENTRATION mg/l
100
80
60
40
20
1967
1968
1969
1970
1971
1972
1973
1974
TIME (YEARS)
SAMPLES 5 2 6 4 2 7 12 3

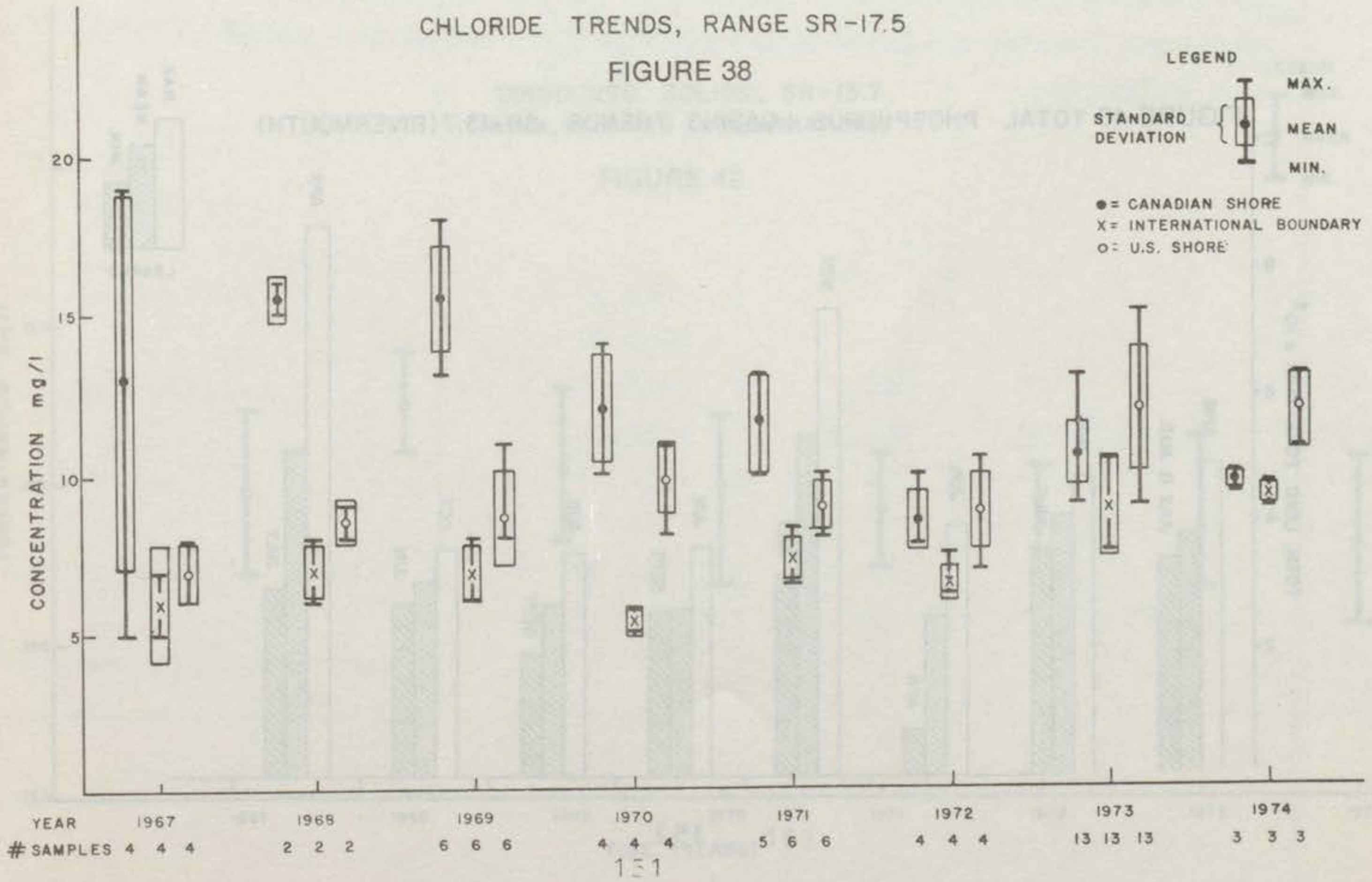

CHLORIDE TRENDS, RANGE SR-17.5
FIGURE 38
LEGEND
STANDARD DEVIATION
MAX.
MEAN
MIN.
● = CANADIAN SHORE
X = INTERNATIONAL BOUNDARY
O = U.S. SHORE
CONCENTRATION mg/l
20
15
10
5
YEAR 1967 1968 1969 1970 1971 1972 1973 1974
SAMPLES 4 4 4 2 2 2 6 6 6 4 4 4 5 6 6 4 4 4 13 13 13 3 3 3

FIGURE 39 CHLORIDE LOADINGS, SR-13.7 (RIVER MOUTH)

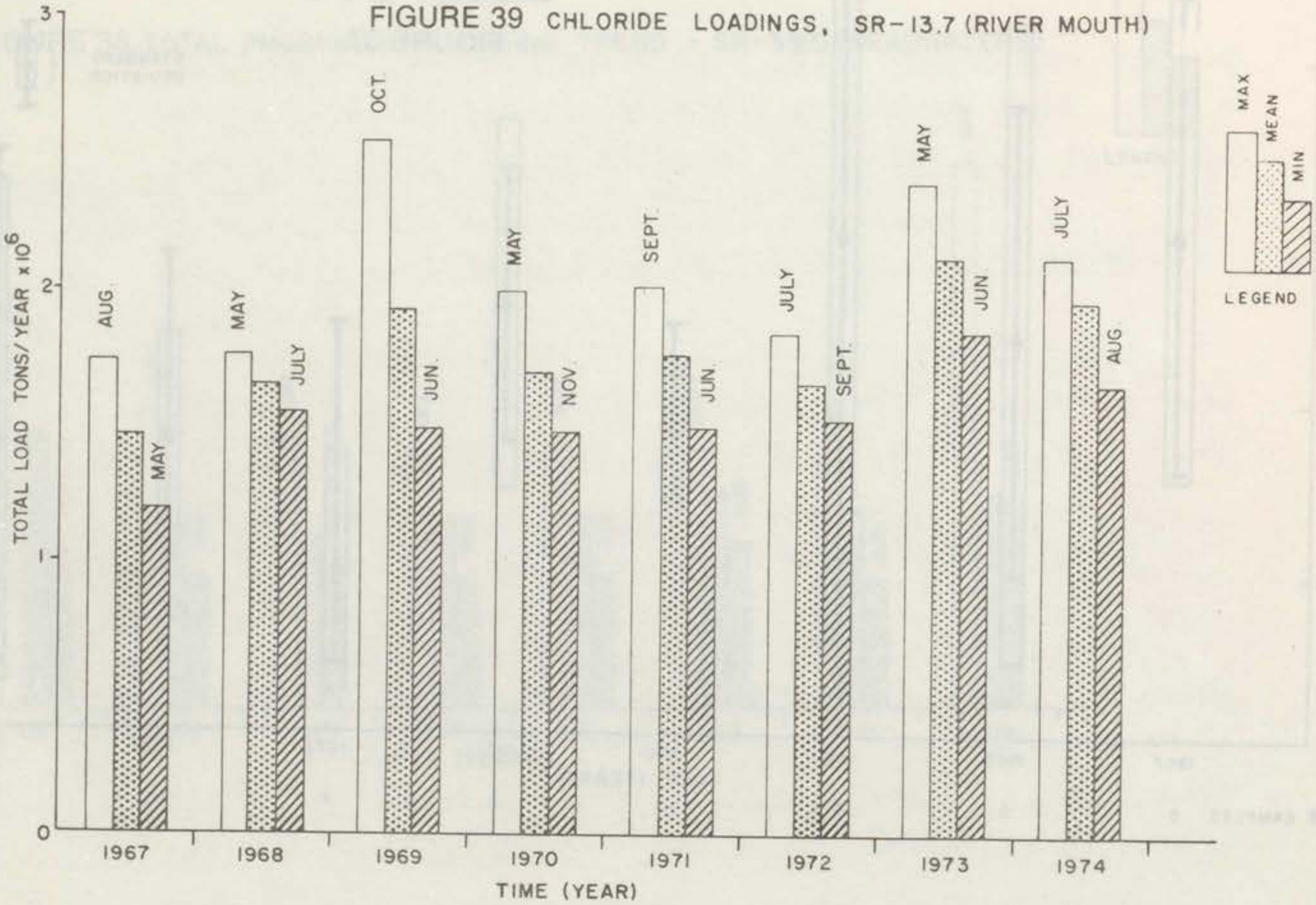
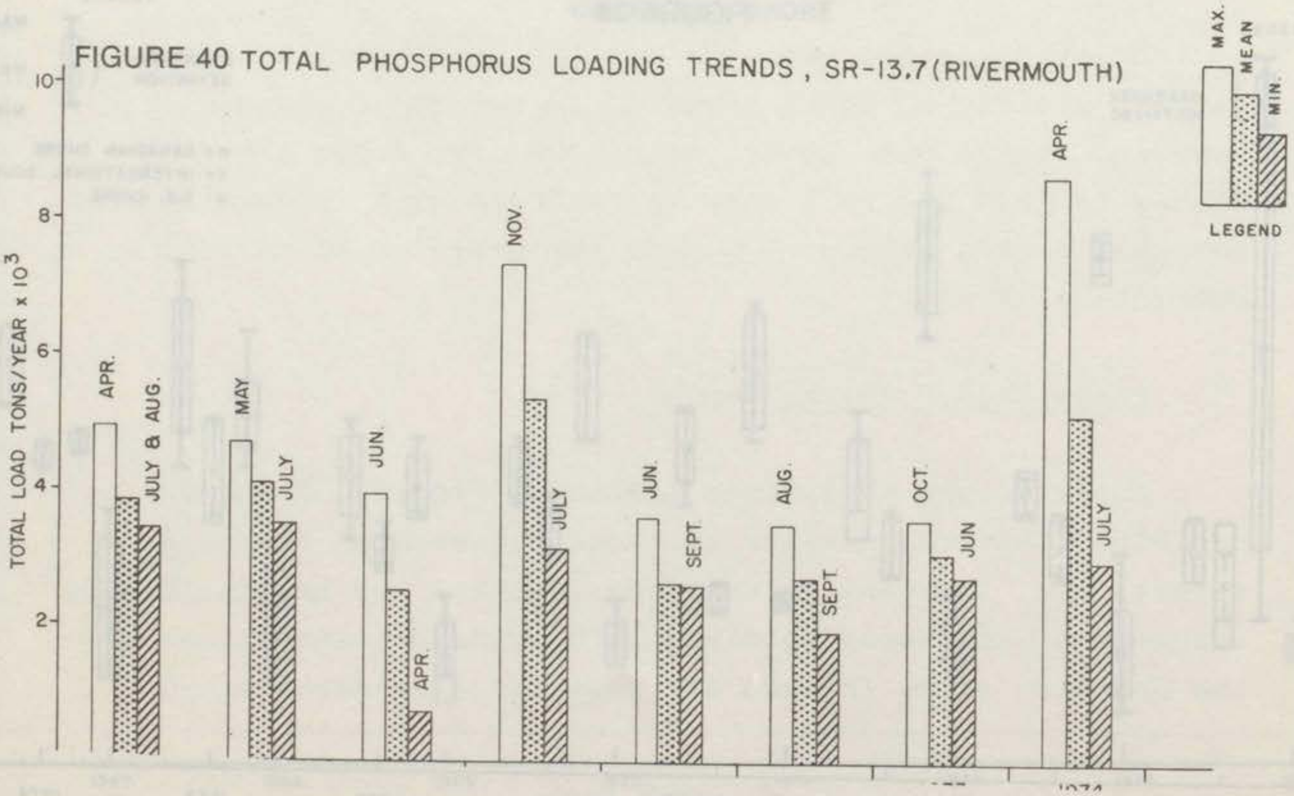
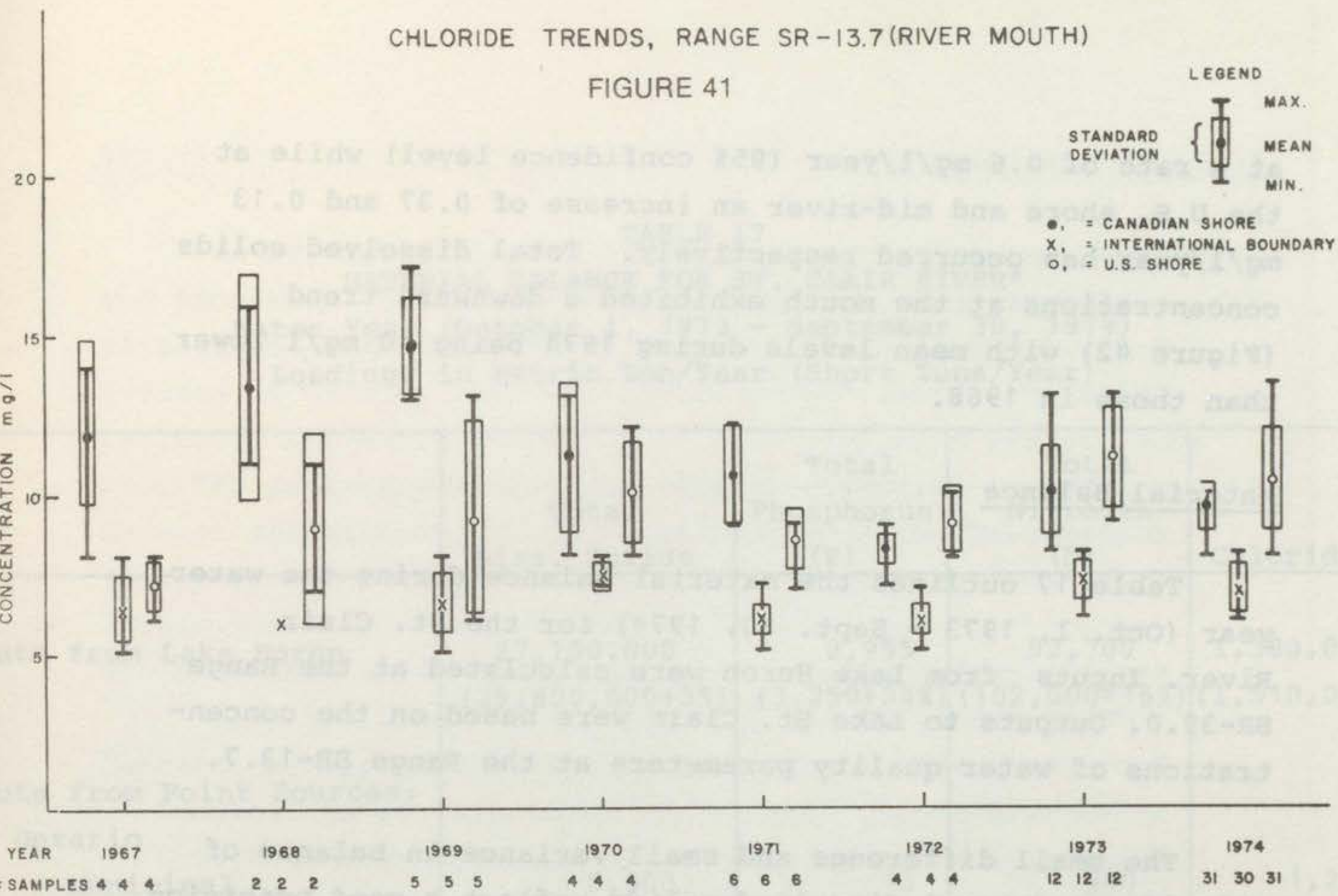


FIGURE 40 TOTAL PHOSPHORUS LOADING TRENDS, SR-13.7 (RIVERMOUTH)



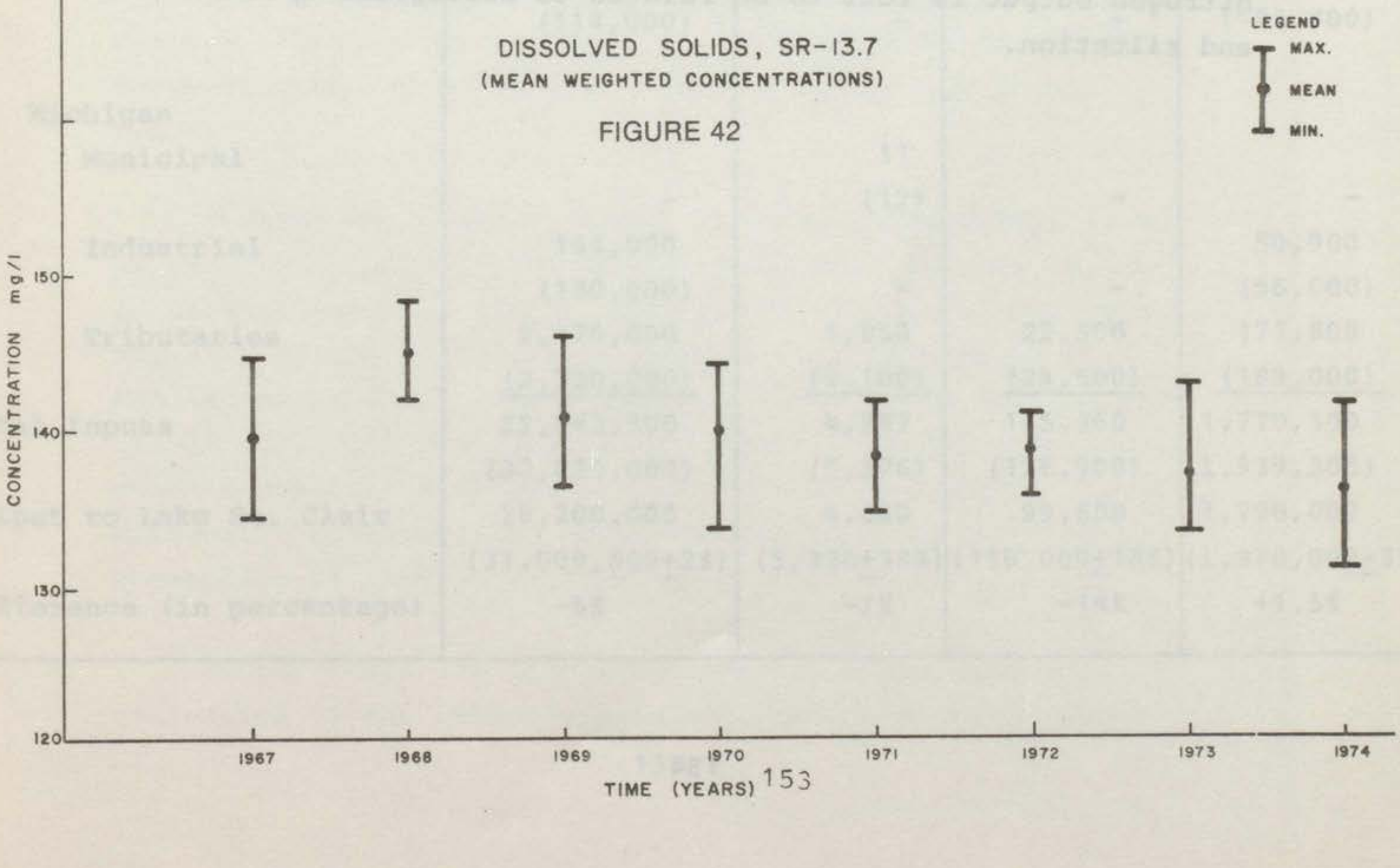
CHLORIDE TRENDS, RANGE SR-13.7 (RIVER MOUTH)

FIGURE 41



DISSOLVED SOLIDS, SR-13.7
(MEAN WEIGHTED CONCENTRATIONS)

FIGURE 42



at a rate of 0.6 mg/l/year (95% confidence level) while at the U.S. shore and mid-river an increase of 0.37 and 0.13 mg/l/year has occurred respectively. Total dissolved solids concentrations at the mouth exhibited a downward trend (Figure 42) with mean levels during 1974 being 10 mg/l lower than those in 1968.

Material Balance

Table 17 outlines the material balance during the water year (Oct. 1, 1973 - Sept. 30, 1974) for the St. Clair River. Inputs from Lake Huron were calculated at the Range SR-39.0. Outputs to Lake St. Clair were based on the concentrations of water quality parameters at the Range SR-13.7.

The small difference and small variance in balance of chlorides and total dissolved solids reflect a good precision in loading calculations. Reduction in the apparent total nitrogen output is felt to be related to biological uptake and siltation.

TABLE 17
MATERIAL BALANCE FOR ST. CLAIR RIVER*
Water Year (October 1, 1973 - September 30, 1974)
Loadings in Metric Ton/Year (Short Tons/Year)

	Total Diss. Solids	Total Phosphorus (P)	Total Nitrogen (N)	Chlorides
Inputs from Lake Huron	27,100,000 (29,800,000±3%)	2,955 (3,250±34%)	92,700 (102,000±16%)	1,380,000 (1,510,000±8%)
Inputs from Point Sources:				
A. Ontario				
Municipal	5,500 (6,000)	13 (14)	360 (400)	1,200 (1,300)
Industrial	104,000 (114,000)	-	-	166,400 (183,000)
B. Michigan				
Municipal	-	11 (12)	-	-
Industrial	164,000 (180,000)	-	-	50,900 (56,000)
Tributaries	2,470,000 (2,720,000)	1,880 (2,100)	22,300 (24,500)	171,800 (189,000)
Total Inputs	29,843,500 (32,820,000)	4,887 (5,376)	115,360 (126,900)	1,770,300 (1,939,300)
Output to Lake St. Clair	28,200,000 (31,000,000±2%)	4,840 (5,320±38%)	99,600 (110,000±18%)	1,790,000 (1,970,000±5%)
Difference (in percentage)	-6%	-1%	-14%	+1.5%

Table 17 continued

1) Total dissolved solids loadings were calculated from conductivity measurements using a conversion factor of 0.63 developed from past data collected by MOE at range SR-39.0.

2) Confidence intervals (expressed in percentage) at 95% confidence limit computed from the variance in the Calculated Loadings.

3) Mean weighted concentrations and loadings at the mouth and headwaters of the river were calculated for each survey and then the yearly loading computed as the arithmetic mean of the survey loadings. It was assumed that the concentration at each sampling point was representative between mid points.

* Loading estimates were corrected to three significant figures.

PERSISTENT CONTAMINANTS IN FISH IN THE GREAT LAKES

For several years most environmental agencies in states and provinces bordering the Great Lakes have monitored a variety of persistent contaminants in fish. Attention has focused on mercury and chlorinated hydrocarbons and their residues, including PCB's. More recently, many surveillance programs have included other metals in addition to mercury. Because of problems in interpretation of data, discussed later, it is difficult to identify trends in contaminant levels over time. Nevertheless, some general conclusions are possible.

Concentration of Metals in Fish

High mercury levels in fish led to the banning of commercial fishing in Lake St. Clair and for walleye in the western basin of Lake Erie in 1970. At that time the regulatory agencies took steps to eliminate industrial discharges of mercury. Monitoring programs were initiated to assess the concentrations of mercury in fish throughout the Great Lakes.

Perhaps the clearest trend in contaminant levels in any of the Great Lakes is the steady decline in mercury levels in fish of Lake St. Clair. Results of testing by the Ontario Ministry of the Environment indicate that in samples of similar sized fish, levels declined 36-64% from 1970 to 1974 (Table 18). The progressive reduction in levels from year to year is evident, although the decline has apparently slowed somewhat. Consideration is now being given to allowing the resumption of commercial fishing on a selective basis.

Mercury data for fish from Lake St. Clair permit an evaluation of the effectiveness of regulatory controls and

TABLE 18

MERCURY LEVELS IN LAKE ST. CLAIR FISHES

Species	Mean Mercury Levels (μg/gm)					% Decline in Mercury Levels 1970-1974
	1970	1971	1972	1973	1974	
Walleye	2.3	1.8	1.4	1.1	1.2	48
Northern pike	4.4	4.9	4.4	2.7	2.5	43
Yellow perch	N.A.[1]	N.A.	N.A.	0.6	0.4	-
Rock bass	N.A.	4.1	2.2	1.1	1.1	-
Smallmouth bass	N.A.	3.3	2.3	1.4	1.5	-
White bass	2.2	2.4	1.9	1.2	0.8	64
Freshwater drum	N.A.	1.3	0.7	0.9	0.6	-
Channel catfish	1.4	1.7	1.3	1.0	0.9	36

[1] Not Available

the dynamics of mercury in large aquatic systems. Previous estimates of the time required for mercury to return to background levels have been as long as 100 years. The data indicate that regulatory controls have led to a rapid reduction in the level of mercury contamination in Lake St. Clair fish.

Trends in mercury contamination elsewhere in the Great Lakes are not so clear. High mercury levels (in excess of 0.5 μg/gm) continue to be found in some fish from localized areas such as the eastern end of Lake Ontario and the western basin of Lake Erie. In other areas mercury levels have apparently declined, as in Thunder Bay and southern Lake Huron, and a resumption of commercial fishing has been possible in some cases.

Information as to contamination by other metals is not as extensive as for mercury. The Great Lakes Fishery Laboratory in Ann Arbor, Michigan, carried out a survey of numerous metals in Great Lakes fish during 1971 and 1972. Elevated levels of arsenic were found in several species from Lakes Michigan and Huron, while slimy sculpins contained high levels of cadmium, chromium and copper. The latter metals did not appear to be concentrated in fish further up the food chain. Nevertheless, the results raise many questions concerning the source, food-chain relationships, and possible effects of these metals in slimy sculpins and other bottom feeders.

Elevated levels of heavy metals have been found in sediments at numerous locations on the Great Lakes, particularly in harbour areas. Accumulation of large quantities of metals have occurred in some cases, as in Hamilton Harbour where up to 930 μg/gm lead and 295 μg/gm chromium were found in sediment samples in 1972. Levels in fish are correspondingly high in some cases. A 1973 comparison of fish from Toronto Harbour and from an unpolluted area of Lake Huron indicated the harbour fish contained some eight times as much zinc and thirty times as much lead as did the Lake Huron fish.

Chlorinated Hydrocarbon Concentrations in Fish

Despite numerous efforts to monitor levels of pesticides and polychlorinated biphenyls (PCB's) in Great Lakes fish, most surveillance programs are of recent origin and relate to very localized areas. Assessment of levels on a lakewide basis is thus difficult.

Trends in contaminant levels are perhaps clearest for Lake Michigan. Annual monitoring of chlorinated hydrocarbons was initiated in 1969 by the Great Lakes Fishery Laboratory. Results to date (Table 19) indicate a steady decline in DDT concentrations following the imposition of restrictions on the use of DDT in Michigan in 1969-70. The trend is consistent across species tested and in some cases is indeed dramatic. The level of DDT in bloaters declined some 87% between 1969 and 1974. As of 1973, DDT residues in coho salmon had decreased below the 5 μg/gm tolerance level established by the U.S. Food and Drug Administration. Levels in lake trout continued to exceed the standard, however.

Limited information is available on DDT contamination in the other Great Lakes. Data collected in 1973 and 1974 under the Upper Lakes Reference Study indicate that fish of Lakes Superior and Huron contain levels of DDT considerably below the U.S.F.D.A. standard. Similarly, residues in fish from Lakes St. Clair and Erie are apparently low, although only limited data are available. Fish from eastern Lake

Ontario were found to contain from 0.75 to 3.81 µg/gm DDT during 1972-73, while fish from Hamilton Harbour averaged less than 1 µg/gm in 1972.

Dieldrin residues in Lake Michigan fish have remained below the U.S.F.D.A. standard of 0.3 µg/gm and show no definite trend (Table 19). Data on dieldrin contamination in the other Great Lakes is limited but suggest that concentrations do not approach the tolerance level.

Mirex, although not used as an insecticide in the Great Lakes region has been reported in fish tissue from Lake Ontario and should be of concern due to its extreme persistence.

PCB levels have been monitored in some of the Great Lakes since 1970. Residues in Lake Michigan fish (Table 19) show no evidence of a downward trend, remaining close to those reported in the earliest tests. Levels are well in excess of the U.S.F.D.A. standard of 5 µg/gm. The data raise concern for human health implications and for possible adverse effects on fish reproduction.

High concentrations of PCB's have also been reported for fish from Lake Ontario. Trout and salmon species taken from the eastern end of the lake in 1972 contained from 5.05 to 12.85 µg/gm while shad contained 4.4 µg/gm.

Available data for Lakes Superior and Huron suggest that PCB residues in fish are considerably below the tolerance level of 5 µg/gm. Levels in Lakes Erie and St. Clair are extremely variable, the highest residues being found in carp (9.3 µg/gm) and channel catfish (4.8 µg/gm). No assessment of trends is possible for these lakes because of the lack of a continuous data series.

TABLE 19

MEAN CONCENTRATIONS OF CHLORINATED HYDROCARBONS IN LAKE MICHIGAN FISH

Year	Species	Total DDT (µg/gm)	Total PCB's (µg/gm)	Dieldrin (µg/gm)
1969	Bloaters	9.94	-	0.27
	Lake trout	-	-	-
	Coho salmon	11.82	-	0.21
1970	Bloaters	9.87	-	0.19
	Lake trout	19.19	-	0.27
	Coho salmon	14.03	-	0.12
1971	Bloaters	6.24	-	0.27
	Lake trout	13.00	-	0.20
	Coho salmon	9.85	-	0.11
1972	Bloaters	4.33	5.66	0.18
	Lake trout	11.31	12.86	0.20
	Coho salmon	7.17	10.93	0.13
1973	Bloaters	2.09	5.24	0.28
	Lake trout	9.96	18.93	0.27
	Coho salmon	4.48	12.17	0.09
1974	Bloaters	1.34	5.46	-

Contamination by chlorinated hydrocarbons has also been reported for birds on the Great Lakes. Herring gull eggs on Lake Ontario were found to contain high levels of PCB and metabolites of DDT. The degree of contamination is correlated with the low breeding success of herring gull colonies in this area which is only one-tenth that of the success of less contaminated colonies on the Atlantic coast. The results indicate a need for expanded monitoring of contaminants in wildlife, as well as fish, on the Great Lakes.

Problems

1. Lack of coordination among resource agencies in conducting monitoring programs. Agencies are often unaware of the nature and scope of each other's programs or even that relevant data exist in the files of other agencies. A centralized data bank is badly needed for the Great Lakes Basin. Upper Lakes Reference Group has established such a system for the Upper Lakes which might well be extended to meet this need over the entire basin.

2. Lack of accessibility of data due to reluctance of agencies to release information for legal or other reasons.

3. Variability in data quality. Contributing factors include a lack of uniformity in analytical methodology and variability in both sample size and range of fish tested. Such variability makes valid comparisons among species and locations difficult.

4. Restricted scope of some sampling programs. Data for many parameters have been collected only in localized areas and are often not representative of other areas. More comprehensive programs incorporating both inshore and offshore areas are needed.

5. Lack of time series data. Identification of trends is often not possible because comparable data are not available for a sufficiently long period of time.

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INTERNATIONAL SURVEILLANCE

PROGRAMS FOR THE GREAT LAKES

WATER QUALITY SURVEILLANCE FOR THE GREAT LAKES - Program Design

Introduction

Reference studies for the IJC in the Great Lakes System seek to identify baseline conditions, problems and sources of pollution. Remedial programs have been instituted to correct identified problems. Water quality objectives have been, and are being developed to define a desirable state of water quality.

Three general categories of problems identified include acceleration of eutrophication or maintainence of a particular trophic state; concern for the presence and impact of toxic substances in the system; and the impairment of water quality by total dissolved and suspended solids introduced into the lake by man's activities. Surveillance programs must address these three subjects.

Goals of a Surveillance Program

Pollution abatement programs have as their objective the control of the loadings of the nutrients which relate to eutrophication, of the loadings of toxic substances, and of the loadings of suspended and other dissolved materials.

Therefore, the first goal of surveillance is to measure directly the loadings from sources affected by remedial programs.

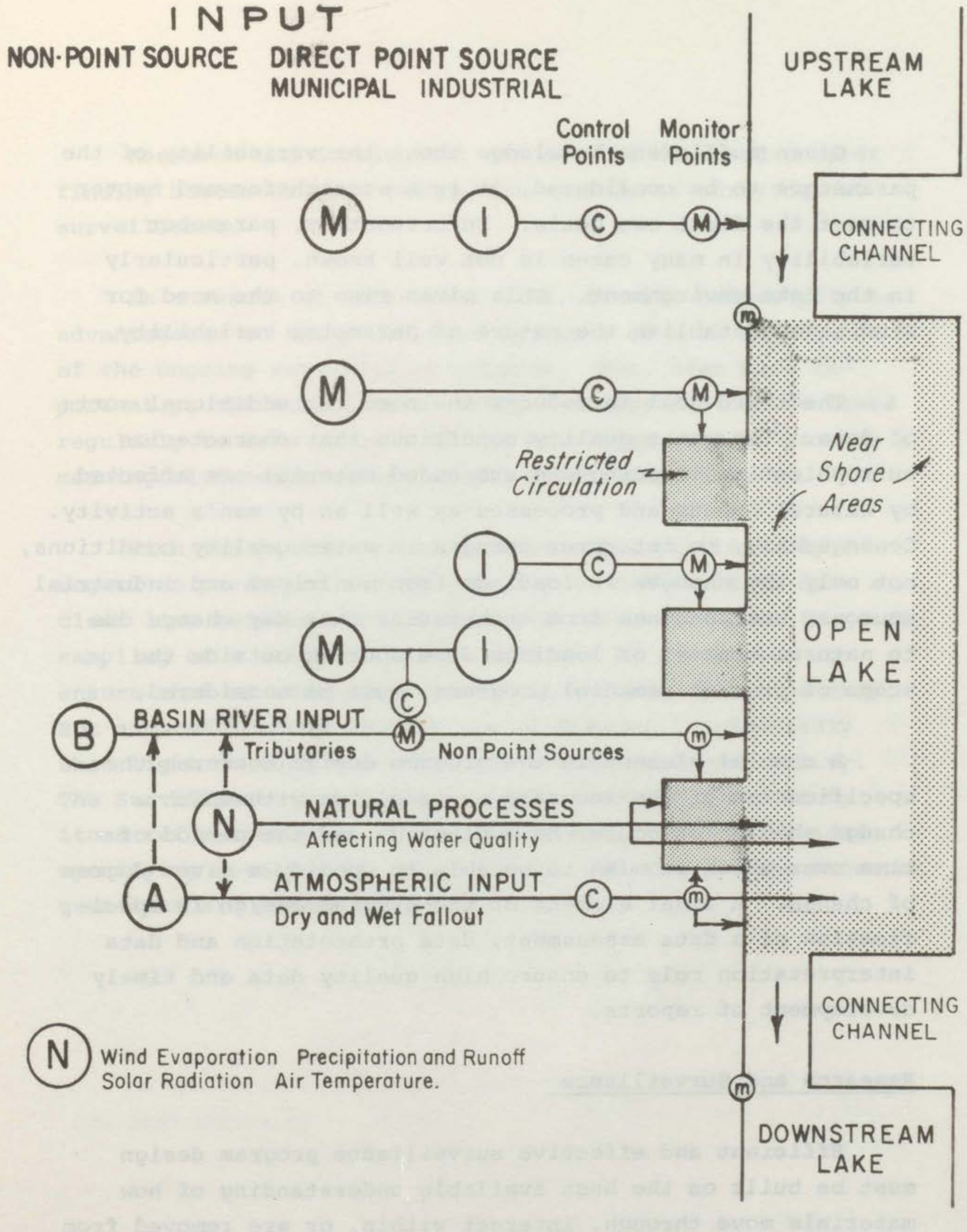
The second goal of the surveillance program is directed towards measurement of conditions in the receiving waters in order to monitor the frequency and intensity of violations of water quality objectives in both localized areas and in the open lakes where changes in problem conditions are to be established.

The final goal of the surveillance program is to provide sufficient data to permit valid interpretation of water quality conditions - this to distinquish the impact of remedial programs from natural changes, both near to and remote from sources. This goal entails documentation of the loadings <u>not</u> under control of present remedial programs as well as monitoring ambient water quality or impacted biota in the system in order to distinguish the impact of controlled loadings from impact from other causes.

Imbedded in these three goals is the need to examine the data to establish whether new problems are developing. A schematic diagram of the system is given in Figure 43.

Elements of the Design

To design a surveillance program is to select a set of parameters sensitive to the water quality condition, and specify the manner in which they should be measured. The latter includes sampling methodology, analytical methods, and the location and frequency with which the parameters should be measured to meet specified accuracy in establishing water quality conditions.



LAKE LOADING SYSTEM

SCHEMATIC DIAGRAM

FIGURE 43

Given sufficient knowledge about the variability of the parameters to be considered, it is a straightforward matter to meet the first two goals. Unfortunately, parameter variability in many cases is not well known, particularly in the lake environment. This gives rise to the need for studies to establish the nature of parameter variability.

The third goal introduces the need for additional sorts of data. The water quality conditions that characterize eutrophication, loading and suspended material are affected by natural events and processes as well as by man's activity. Consequently, to interpret changes in water quality conditions, not only the changes in loadings from municipal and industrial sources, but loadings from tributaries that may change due to natural causes, or loadings from sources outside the scope of present remedial programs, must be considered.

A crucial element in the program design concerns the specification of the accuracy or precision with which a change should (or could) be monitored, and the period of time over which we wish to be able to specify a given degree of change. A final element of the program design is specification of a data assessment, data presentation and data interpretation role to ensure high quality data and timely development of reports.

Research and Surveillance

Efficient and effective surveillance program design must be built on the best available understanding of how materials move through, interact within, or are removed from the system. This understanding is the product of research - research into the surveillance data itself or studies executed separately from the surveillance program.

Research and development can also be directed towards finding better or more economical methods of carrying out surveillance.

As a result of this close link, it will undoubtedly be advantageous to carry out some research as a close adjunct of the ongoing surveillance program. But, even more importantly, the surveillance program design must be reviewed regularly to take account of new knowledge, and to provide a meaningful interpretation of the conditions observed.

With the present state of knowledge, particularly in regard to parameter variability, it is difficult to draw a clear line between surveillance and research. More frequent sampling of a critical parameter might be undertaken to ensure that an accurate statistical assessment can be made. But a careful study of that set of data will undoubtedly shed light on much more than its statistical variability. The Surveillance Subcommittee has introduced a few study items reflecting some immediate concerns, but has avoided specifying detailed or comprehensive research. Some research questions are posed, however.

MONITORING OF LOADINGS

L 1 - Tributary Loading

Objective

The purpose of tributary monitoring for the Great Lakes is to provide estimates of an important component of loadings to the system. Changes to loadings to the lakes are not necessarily reflected in immediate changes in water quality. Trends in loading provide the basis for estimating future variations.

Plan Summary

The significant tributaries to be monitored for each lake have been identified by the individual jurisdictions for their area of responsibility. The number of tributaries to be monitored for each lake is as follows:

Lake Ontario	-	21
Lake Huron	-	26
Lake Erie	-	22
Lake Michigan	-	33
Lake Superior	-	29
Lake St. Clair	-	3

In addition, 16 tributaries have been identified as significant for the connecting channels. The parameters and frequency of sampling are specified in Table 20.

Research Requirements

Due to the uncertainty expressed in many areas regarding the adequacy of the present basic monthly strategy of tributary monitoring, it is expected that the tributary program will be in effect for a maximum of two years while research programs are undertaken concurrently to establish the optimum sampling strategy. Examples of this sort of study are those being carried out by the U.S. Buffalo Corps. of Engineers in the Lake Erie Waste Water Management Study. In its most sophisticated form, it is anticipated that sampling frequency will be a function of both parameter and stream characteristics.

It is already clear from Ohio reports that present reported loadings will have to be re-assessed in the light of more frequent sampling for major tributaries. Preliminary results presented to the Surveillance Subcommittee by U.S. Buffalo Corps of Engineers have also pointed out potentially large errors in loading estimates based on inadequate sampling frequencies for suspended solids. Reseach should include the requirement to better assess the quality and effects of suspended solids and bed load total on the lakes. The Surveillance Subcommittee has identified the Maumee and Cuyahoga Rivers in Ohio, and the Grand River in Ontario, as major contributors of phosphorus to Lake Erie and recommends that pilot studies be undertaken on these rivers with priority being placed on phosphorus to address the problems indicated. Related studies are by New York State, and the Pollution from Land Use Activities Reference Group.

Reports

Annually

Agencies Involved

All jurisdictions.

TABLE 20

LIST OF PARAMETERS AND FREQUENCY OF SAMPLING FOR TRIBUTARY SURVEILLANCE PLAN

FREQUENCY	PARAMETER
Continuous	Flow
Monthly	Iron
Monthly	pH
Monthly	Coliform
	Total
	Fecal
Monthly	Dissolved Oxygen
Monthly	BOD_5
Monthly	Silicate
Monthly	Conductivity/TDS
Monthly	Turbidity
Monthly	Total Phosphorus unfiltered
Monthly	Soluble Reactive Phosphorus (report ASP)
Monthly	Ammonia
Monthly	Total Kjeldahl Nitrogen
Monthly	Nitrite and Nitrate
Monthly	Temperature
Monthly	Suspended Solids
Monthly	Settleable Solids
Monthly	TOC
Monthly	Chloride
Monthly	Oil and Phenols (only in known problem areas)
SEMI-ANNUALLY	Cadmium
(APRIL & AUGUST)	Chromium

TABLE 20 (continued)

FREQUENCY	PARAMETER
Semi-Annually	Copper
	Lead
	Nickel
	Selenium
	Zinc
	Arsenic
	Barium
	Mercury
	Fluoride
	Sulphate
	Pesticides
	PCB's
	All metal analyses will be done on filtered and unfiltered samples.

TABLE 21

SURVEILLANCE PROGRAM COST ESTIMATES
(thousands of dollars)

		1975/76 Ongoing	1975/76 Program Level	1976/77 Program Level	1977/78 Program Level	1978/79 Program Level
Whole Lake (1)	Can.	450	550	750	780	820
	U.S.	400	440	990	1310	1440
Near Source (2) and Near Shore	Can.	670	670	710	780	885
	U.S.	100	930	1020	1120	1230
Connecting (3) Channels	Can.	440	340	390	510	460
	U.S.	110	360	440	400	540
Water	Can.	20	180	200	220	240
	U.S.	35	310	340	370	410
Tributary (4) Measurements	Can.	180	260	285	315	345
	U.S.	180	250	275	305	335
Atmospheric Loading	Can.	70	95	80	85	95
	U.S.	10	115	90	95	105
Wildlife	Can.	100	100	100	100	100
	U.S.					
Fisheries		Program being developed - A number of potential components in operation already, but not yet integrated into a program.				
TOTALS	Can.	1930	2195	2515	2790	2945
	U.S.	835	2405	3155	3600	4060

Table 21 cont'd

(1) The Whole Lake program includes:

(a) estimates of annual programs for all lakes
(b) estimates for special surveys
(c) estimates for data management and analysis
(d) estimates for remote sensing operations
(e) funds allocated by the United States for a three year baseline study of Lake Michigan commencing in 1976/77

(2) Near Sources Monitoring estimates are based upon a four year cycle for the Lower Lakes and Lake Michigan (two intensive sampling years and two years at a reduced level) and a six year cycle for Lakes Superior and Huron (two years intensive and four reduced). The program is initiated with intensive years in Lakes Huron and Erie in 1975/76.

A number of municipal programs for waterfront surveys in the United States are in existence for which cost figures have not been included.

(3) The figures indicate a sediment and biological survey undertaken each year on one specific channel in the following order: Detroit River (1976/77); St. Clair River; Niagara River; St. Lawrence River; and the St. Marys River. It should be noted, due to the detailed planning and logistics involved in surveys of this nature, that slippage of one year may result.

The estimates for 1975/76 include a special loading study on the Detroit River.

(4) Ongoing funds do not necessarily reflect total actual expenditure due to the difficulty of assessing the cost of flow measurement.

Project Costs

Refer to Table 21.

L 2 Municipal and Industrial Loading

Objective

To determine the material loadings to the Great Lakes System from direct municipal and industrial discharge by source monitoring.

Rationale

It is recognized that the optimum method of determining loadings from individual dischargers is to monitor at the source thus eliminating the masking effects of dilution and natural variations which occur once the material enters the lakes system.

Plan Summary

The permits issued by U.S. EPA or authorized state agencies under the National Pollutant Discharge Elimination System limit the amount and concentrations of waste materials that may be discharged by each industry and municipality. Each discharge is also required to sample the discharge in accordance with approved methodology and on a time schedule established by the permit. The results of the sampling are forwarded to the permit issuing agency on a regular time schedule and are available to IJC for loading calculations. The issuing agency makes periodic field surveys to verify the self-monitoring information.

Ontario Ministry of the Environment

The Ontario Ministry of the Environment conducts surveys of industrial effluents quarterly to determine the concentration and volume of waste materials being discharged to the provincial waters. This information is compared with the self monitoring data from the continuous measurements by industry for varification. The loading information obtained by MOE field measurements is forwarded to IJC.

Direct municipal effluents are surveyed basically monthly and twenty-four hour composite samples taken from both the raw input and final effluent taken except where the plants are not manned for full twenty-four hour periods. The average for the twelve composites is multiplied by the yearly average daily flow to compute an average daily loading estimate. The loading information is forwarded to IJC.

Reports

Annually

Agencies Involved

All jurisdictions.

Project Costs

Only minimal additional costs to the jurisdictions for retrieval of the data are assumed since the information is gathered as part of a total state or provincial regulatory system.

Data Quality Assurance

For industrial source data some jurisdictions have found it profitable to develop a data quality assurance system to ensure comparability of data generated by various labs. This is heartily encouraged by the Subcommittee.

The municipal discharge loading is the subject of a study as outlined in a proposal to the Water Quality Board from the Regional Office.

L 3 Atmospheric Loading

Objectives

To determine the material loadings to the Great Lakes via direct atmospheric precipitation (wet and dry deposition).

To determine time-trends in the chemical composition of atmospheric precipitation of the Great Lakes basin and the effect of this on loadings to the Lake.

Rationale for Program

Previous studies on precipitation chemistry in the Great Lakes basin have indicated that atmospheric precipitation can be a significant source of nutrients and/or trace metals to the Lakes. For phosphorus estimates have ranged from 1% of the total load for Lake Erie to about 50% of the total load from preliminary estimates for the Upper Lakes. It has been shown that atmospheric precipitation may make an even greater contribution in the case of the trace metals. It is important therefore that some program be mounted to determine the contribution of atmospheric precipitation to the materials budgets of the Great Lakes.

Brief Outline of Proposed Program

The program will consist of two types of sampling for wet deposition (rainfall and snowfall) and for dry deposition (particulate fall-out). The study on atmospheric inputs to the upper Great Lakes now being carried out for the Upper Lakes Reference Group and studies presently being conducted by the Atmospheric Environment Service, Environment Canada have indicated that this is the most viable way of determining atmospheric loadings.

Wet Deposition Sampling

Twenty to twenty-two (provisional) wet deposition sampling stations are proposed for the entire Great Lakes basin spread approximately unfiromly in the basin. There will be more stations in the U.S. portion of the basin because the Lake Michigan basin is entirely within the U.S. These stations will be equipped with the AAPS automatic rain samplers. Monthly integrated samples of the rainfall and snowfall will be collected and analysed and wet deposition rates calculated ($mg/m^2/da$). The parameters will include nutrients, trace metals and some major ions.

Dry Deposition Sampling

Hi-Vol air particulate samplers will be located at about 6 of the wet deposition stations to sample the suspended particulate material in the air. The collected particulate matter will be analysed for essentially the same parameters as in the case of the wet depositon samplers. These data can then be used to estimate the dry deposition rates ($mg/m^2/da$).

Loading Estimates

The wet and dry deposition rate will be combined to give the total atmospheric deposition rates. These deposition rates will be used to estimate total direct lake surface loadings. Loadings to the land surface and the eventual import of these on land drainage loadings to the lake will not be addressed by this program.

Research and Development Requirements

In a relatively new type of surveillance program such as this, it is not surprising that there are a number of areas related to the program and methodologies used in the program that requires research and development. A few of these are listed.

1) Development of methodology for sampling for organics in rainfall.
2) Minimization of evaporation loss in sample design.
3) Development of dry deposition sampling methods.
4) Development of lake surface wet and dry deposition samplers.
5) Research into the forms of phosphorus, nitrogen, and trace metals in rainfall and their availability.
6) Research into trace methods for determining material and man-made sources of substances in wet and dry deposition.

Reports

Annually

Agencies Involved

CCIW and U.S. EPA Grosse Isle

Project Costs

Refer to Table 21.

L 4 Connecting Channels Loading

Refer to Impact Surveillance program item I 1.

IMPACT SURVEILLANCE

I 1 Connecting Channels

Objectives

To monitor the water quality of the connecting channels of the Great Lakes System in order to determine compliance with the water quality objectives established in the Great Lakes Agreement.

To investigate and determine the fate of contaminants in the connecting channels.

To determine trends in the water quality of the connecting channels in order to provide information relevant to the need for, or assessment of, remedial programs.

To accurately determine loadings for the connecting channels in order to calculate material balances at the head and mouth of the connecting channels for the Great Lakes.

Plan Summary

See Subsections for each separate channel.
See Table 22 for the standard minimum list of parameters.

Research Requirements

At present the channel plans submitted lack uniformity which, as in the tributaries, stems from a lack of knowledge of optimum sampling frequency and the best mathematical approach for loading calculations.

TABLE 22

CONNECTING CHANNELS

SURVEILLANCE PARAMETERS

Physical	Nutrients
temperature	total and soluble phosphorus
pH	nitrate + nitrite (soluble)
dissolved oxygen	ammonia (soluble)
conductivity	total kjeldahl nitrogen
turbidity (secchi depth)	silicate
suspended solids	
settleable solids	**Biological**
Conservative Major Ions	chlorophyll a (head & mouth)
	biota (head & mouth)
chloride	
sulphate	**Bacteriological**
fluoride	
	total coliforms
***Trace Metals & Toxic Substances**	fecal coliforms
total chromium	**Organic**
total iron	
total lead	phenols
total zinc	BOD_5
total copper	TOC
total nickel	
total mercury	
total arsenic	
pesticides & PCB's	
total selenium	
radioactivity	
* annually	

In addition, further information is required to assess the availability of phosphorus for biological uptake. It is recommended by the Surveillance Subcommittee that pilot studies be undertaken to solve the problem. The pilot studies should concentrate on the Detroit River, which is given first priority due to its effect upon Lake Erie. A Task Group of the Subcommittee is to provide, in the near future, the scope of the studies necessary to complete this undertaking. One such study has been identified to address the phosphorus loading question. An additional study of the flow distribution at the lower ranges of the Detroit River by the U.S. Army Corps of Engineers has been encouraged and is required for this study as well. Additional such flow distribution measurements will be required for other connecting channels.

It is anticipated that the connecting channels will be monitored in accordance with the present plans proposed; however, when the results of the pilot studies are assessed within one year, an attempt will be made to unify all plans.

<u>Project Costs</u>

Refer to Table 21.

<u>I 1.1 St. Lawrence River</u>

<u>Plan Summary</u>

A total of seventy-one stations located above and below major inputs to the river, with some stations in the mouths of the main tributaries will be sampled eight times a year (except those stations sampled for loading estimates), including one survey during the winter period. Most station samples will be surface samples. The western transects, which will be used for loading estimates, will be sampled at the surface and mid-depth (due to possible stratification) with a minimum monthly frequency.

Bottom fauna and sediment quality sampling will also be done. Bottom fauna sampling will be coordinated with the sediment quality sampling and sites will be selected for both from the water quality stations. For biological sampling, three to five replicates will be taken at each site which will be mainly in an area where deterioration of water and sediment quality is suspected. Surface sediment samples will be taken and analyzed for total heavy metals, pesticides, PCB's, oil and grease, COD, volatile solids, total phosphorus and benthic species at each point once each year.

Two stations will be established for continuous monitoring of conductivity, chloride and turbidity and water samples will be taken at preset intervals for nutrient and heavy metal analyses.

Reports

Annually for general assessment purposes and approximately every three years, as per the agreed schedule, for the detailed assessment.

Agencies Involves

CCIW will provide the major agency input.

I 1.2 Niagara River

Plan Summary

Sampling ranges are established on both the Upper and Lower Niagara River. Stations are located one hundred feet from shoreline of each side, at the one quarter point and the three quarter point. Samples should be taken at surface, mid-depth and bottom on a minimum monthly frequency. In addition eight stations with availability of historical data are incorporated.

Sediment samples should be taken once a year for all stations at or near the river source at the same time that water quality range samples are taken. Sediment parameters will include total phosphorus, oil, PCB's, heavy metals, pesticides, radioactivity, COD, volatile solids and benthic species.

Reports

Annually for general assessment purposes and approximately every three years for the detailed assessment.

Agencies Involved

The major agency input will be provided by New York Department of Environmental Conservation and EPA Region II.

Ontario Ministry of the Environment will provide limited input to the Upper Niagara.

CCIW will undertake additional experimental work.

I 1.3 Detroit River

Plan Summary

A total of fifty-four stations at ten ranges will be sampled, with special emphasis on the ranges at the head and mouth of the river, at monthly intervals during the ice-free portion of the year. Monthly samples will be taken for parameters for which specific IJC objectives are set, important nutrients and others as needed. Annual samples will be taken for those parameters which IJC is reviewing for establishment of specific objectives.

Report

Annually for general assessment purposes and approximately every three years for the detailed assessment.

Agencies Involved

Michigan Department of Natural Resources will provide the major agency input.

Ontario Ministry of the Environment will provide limited input to the head and mouth ranges.

Project augmentation for the collection of additional data regarding loading to Lake Erie is under consideration by EPA Region V Michigan Department of Natural Resources and the Ontario Ministry of the Environment.

I 1.4 St. Clair River

Plan Summary

Ranges established by the IJC for the 1946-48 surveys along with others added since that time to provide surveillance of new waste sources are recommended for continued monitoring.

At the present time nine transects encompassing forty-five stations are considered adequate to assess receiving water compliance with agreement objectives below major waste sources as well as monitoring key constituent loadings into and out of the river.

Eight surveys at monthly intervals are planned for the period from April to November each year. During each survey three complete runs of the river will be attempted providing a total of twenty-four samples per station over the year. Samples will be collected at one meter below the surface and at depth were significant vertical variation in quality exists.

A detailed examination of the benthic macroinvertebrate community and sediment characteristics are to be undertaken at three year intervals or more frequently as significant changes in waste loading dictate. A grid designed to delineate the effects of specific waste sources and to trace downstream recovery will be employed. Visually similar samples will be composited from separate casts for grain size and chemical analyses and three discrete samples from separate casts will be collected for fauna identification and enumeration at each point.

Report

Annually for the general assessments and approximately every three years for the detailed assessment.

Agencies Involved

U.S. EPA V, CCIW, MOE. Ministry of the Environment will have the lead responsibility.

I 1.5 St. Mary's River

Plan Summary

Ranges established by the IJC for 1946-48 surveys along with others added since that time in recognition in changing shoreline development are recommended for continued monitoring.

At present eight transects encompassing forty stations are considered adequate to assess receiving water compliance with agreement objectives below major waste sources as well as monitoring key constituent loadings into and out of the river.

Three or four surveys are planned each year for the period from April to November. During each survey nine complete runs of the river will be attempted providing a total of twenty-seven to thirty-six samples per station over the year. Samples will be collected at one meter below the surface and at depth where significant vertical variation in quality exist.

A detailed examination of the benthic macroinvertebrate community and sediment characteristics is to be undertaken at three year intervals or more frequently as significant changes in waste loading dictate. A grid designed to delineate the effects of the specific waste sources and to trace recovery downstream will be employed. A composite of two visually similar samples from separate casts will be obtained for grain size and chemical analyses and three discrete samples from separate casts will be collected for fauna identification and enumeration at each point.

Report

Annually for the general assessments and approximately every three years for the detailed assessment.

Agencies Involved

U.S. EPA V, CCIW, MOE. Ministry of the Environment will have the lead responsibility.

I 2 Lakes - Whole Lake

Objectives

To measure the water quality of the lakes to determine compliance with the IJC Objectives.

To determine levels and trends of chemical, physical and biological constituents of water quality in the lakes, particularly as they relate to entrophication, indicate emerging problems and the effectiveness of remedial programs in the Great Lakes Basin.

To measure and calculate loadings and material balances for water quality management.

Plan Summary

As originally stipulated, detailed surveillance plans would be drafted for each lake in turn. For the purposes of this years annual report plans have been formulated for most phases for Lake Erie as the first priority for lake surveillance and Lake St. Clair. The individual plans summaries are contained in subsections I 2.1 and I 2.2.

Generally, surveillance of all lakes will be carried out on an annual basis with intensive survey years for each lake occurring once every five years for Lakes Ontario, Erie and Michigan on a rotating basis. Longer periods between intensive survey years will be considered for Lake Superior and Lake Huron since changes may be slower in the main body of the lake. An increase will occur in the year prior to the intensive one for each lake in biological sampling to provide two years of biological data within each of these more intensive components.

Research Requirements

Specific studies should be undertaken to determine the distribution of loading over time and the lake response relationship and the availability of materials available for biological uptake with emphasis being placed on phosphorus.

Project Costs

Refer to Table 21.

I 2.1 Lake Erie

Plan Summary

The annual surveillance plan for Lake Erie is based upon the EPA Grosse Ile and CCIW plan for Lake Erie to monitor the oxygen depletion rate and the severity of dissolved oxygen depletion, as well as the areal coverage of the depletion. In addition the phosphorus budget and total dissolved solids trends will be examined.

The program involves seventy-five stations monitored during a minimum of eight cruises: four of which will be undertaken in the summer months; two in the spring; and two in the fall. At each station a maximum of six depths will be sampled if a thermocline exists as follows: Hypolimnion - two samples (top and bottom); Thermocline - one sample; and Epilimnion - three samples (equally spaced). Table 23 indicates the parameters and frequency of sampling required.

Reports

General assessment reports will be provided annually with detailed reports every five years following the intensive survey.

Agencies Involved

EPA, CCIW.

TABLE 23

LAKE ERIE

SURVEILLANCE PARAMETERS AND FREQUENCY

PARAMETER	NUMBER SURVEYS	ALL STATIONS	COMMENTS
Dissolved Oxygen	8	x	
Temperature	8	x	
Chlorophyll 'a'	8	x	
Total Phosphorus			
Filtered	4	x	Spring and Fall
Unfiltered	4	x	Spring and Fall
Soluble Reactive Phosphorus - Filtered	2	x	
Chloride	4	x	
TDS	1	x	Possibly replaced by conductivity
Fish Contaminants			To be investigated further
Settleable Solids			To be investigated further

In addition, observations of oil slicks during monitoring cruises will be reported.

I 2.2 Lake St. Clair

Plan Summary

The Lake St. Clair monitoring consists of four basic phases which include:

(a) Periodic monitoring at water intakes (see I 4) at selected water intakes.

(b) An intensive survey every five years during which a network of stations will be sampled a minimum of twelve times including depth samples. Parameters include the water intake parameters plus seston, zooplankton, phytoplankton, total plate counts dissolved oxygen and TOC.

(c) Sediment chemistry and benthos mapping carried out in conjunction with the intensive survey years to detect accumulation of pollutants in sediments and monitor the biota of the lake. The parameters to be monitored include phosphorus, oil and grease, COD, volatile solids, total kjeldahl nitrogen, heavy metals, pesticides, PCB's, size analysis and benthos.

(d) Possible remote sensing overflights during the intensive survey year to determine lake-wide distributions of chlorphyll and surface temperature patterns.

Reports

Annually for general assessment and every five years approximately, following the intensive survey years.

Agencies Involved

EPA, CCIW.

I 3 Lakes - Near Sources Sampling

Objectives

To determine the extent of areas of non-compliance with the general and specific water quality objectives of the Agreement adjacent to major waste sources and identify sources contributing to this violation.

To provide the basic data needed to examine trends in water quality for areas subject to the influence of specific waste sources.

Rationale

Near source monitoring will provide an indicator of the efficacy of remedial programs in view of the fact the areas surrounding source inputs will respond most rapidly to a reduction to the system. This will be evidenced by changes in the water quality gradient from shore to deeper waters and a reduction in regime variability along the shoreline.

Basic Program

Monitoring programs will be undertaken in the vicinity of major metropolitan areas and the mouths of tributaries which provide large loadings to the lakes system. Approximately five to fifteen stations will be monitored at a frequency of five to fifteen times per year. The actual sampling station array and parameter selection will be established by the applicable jurisdiction and will depend upon the nature of the problem.

The sampling undertaken in these areas will also be synchronized with the large vessel monitoring of the near shore stations which form part of the 'whole lake' program in order to provide an indication of the water quality regime along the shoreline.

Reports

Annually

Agencies Involved

All jurisdictions.

Project Costs

Refer to Table 21.

I 4 Lakes - Water Supply Intakes

Objectives

To measure the water quality of the lakes to determine compliance with the IJC Objectives.

To determine levels and trends of chemical, physical and biological constituents of water quality in the lakes and indicate emerging problems and the effectiveness of remedial programs.

Rationale

Water intakes provide historical data for comparison purposes and sampling locations which are easily accessible.

They also provide the possibility of year long sample collections by eliminating problems associated with winter field conditions. Water supply intakes will be valuable in providing supportive data to the whole lake program during the years when the whole lake monitoring is done at reduced levels.

Plan Summary

A uniform set of parameters has been devised for water intake sampling throughout the Great Lakes System (Table 24). In general terms it is felt that approximately nine to eleven intakes will provide sufficient information for each of the Great Lakes. The intakes will be selected as much as possible to monitor lake waters representative of the open lake (one of the tasks of the intensive 'whole lake' program will be to determine the respresentativeness of various intakes).

Project Costs

Refer to Table 21.

I 4.1 Lake Erie

Plan Summary

Eleven water intakes have been identified in Table 25 for monitoring in the Lake Erie program with attempts made to provide adequate coverage within each basin of the lake.

Reports

Annually

Agencies Involved

MOE, Michigan DNR, Ohio EPA, NYDEC.

TABLE 24

LIST OF PARAMETERS AND FREQUENCY
FOR WATER INTAKE SAMPLING (1)

PARAMETER	FREQUENCY	COMMENTS
Iron	Weekly	
pH	Weekly	
Coliform		
Total	Weekly	
Fecal	Weekly	
Silica	Weekly (2)	
Phosphorus	Weekly (2)	
Nitrogens	Weekly (2)	
Turbidity	Weekly	
BOD_5	Weekly	
Conductivity	Weekly	
Temp	Weekly	
Chloride	Weekly	
Oil		As required
Phenols		As required
Cadmium	Once per year (3)	
Mercury	Once per year	
Chromium	Once per year	
Copper	Once per year	
Lead	Once per year	
Nickel	Once per year	
Selenium	Once per year	
Zinc	Once per year	
Arsenic	Once per year	
Barium	Once per year	
Fluoride	Once per year	
Sulphate	Once per year	
Pesticides	Once per year	
PCB's	Once per year	
Chlorophyll 'a' (4)		
TOC	Weekly	
Taste and Odour		As reported by operators

TABLE 24 CONT'D

(1) Methods are being addressed by the Committee on Data Quality. Until uniform methods are specified present methods will be used.

(2) Subject to further examination.

(3) The monitoring of parameters with a specified frequency of annually will coincide with one of the tributary sampling periods. These parameters will be subject to review when representativeness of water intake information is studies.

(4) To be sampled at several selected intakes intensively to determine diurnal variation. Frequency will vary from hourly for several days at these plants, the basic frequency will probably be weekly at the remaining locations, but this is subject to change based upon assessment of intake data by the jurisdictions.

TABLE 25

WATER INTAKES TO BE MONITORED FOR LAKE ERIE

STATE/PROVINCE	WATER INTAKE	BASIN
Ontario	Kingsville (Union)	Western
	Blenheim	Central
	Dunnville	Eastern
Michigan	Munroe	Western
Ohio	Oregon	Western
	Sandusky	Western
	Cleveland Crown	Central
	Painesville	Central
Pennsylvania	Erie	Central/Eastern
New York	Buffalo	Eastern
	Dunkirk	Eastern

I 5 Fisheries Program

Contaminants entering the Great Lakes are found in lake biota at concentrations greater than in the water itself. The biota have value as natural monitors of water quality because they integrate all stresses placed on an aquatic ecosystem (including ambient physical and chemical parameters of water quality) and reflect the combined effect of such stresses. Some contaminants are concentrated at each stage of the food chain and at the higher trophic levels the predatory fish have elevated concentrations which are more amenable to accurate measurement, and thus represent a convenient point of focus for impact surveillance.

Fish are a valuable resource in the Great Lakes and as such must meet food quality standards. In addition, in order that fish stocks be maintained at desirable levels, a surveillance program directed at elements of the biological significance of the contaminants should be addressed.

We are advised that Canadian officials are undertaking a review and summary of existing research and inspection data, as a preliminary to specification of just such a program.

There are other matters in which fisheries and water quality interrelate. Water quality may have some more direct impact upon spawning areas (e.g. silting), fish food and feeding locations, and impair the preferred habitats of desirable fish species. For example, eutrophication can give rise to low dissolved oxygen levels in the colder waters of the hypolimnion, thus eliminating the preferred habitat of some species. Waste heat provides a new habitat that can give rise to predominance of different species in that area.

Thus there exists the potential for a surveillance program to serve both fisheries and water quality concerns. A surveillance program consisting of assessment of physical-chemical parameters of water quality, supported by relevant biological assessment, will provide a more accurate and continuous record of water quality.

I 6 Wildlife Program

As in the case of fish at the higher trophic levels, contaminants are found in aquatic birds. Great Lakes Herring Gulls have amongst the highest concentrations of numerous organochlorine contaminants of any wild bird populations. It is proposed that measurement of annual trends of toxic chemicals in Herring Gull eggs be carried forward through collection of 10 eggs to each of 2 sites on each lake. Negotiations are under way to arrange for collections from Lake Michigan so that all lakes will be covered.

The biological significance of these toxic contaminants will be studied through monitoring of productivity, since initial research suggests a clear inverse association between contaminant levels and productivity. The occurence of these high contaminant levels also presents the opportunity to examine the material for as yet unidentified compounds that may be significant.

Finally the material will be examined for chromosome abnormalities.

Field collections were carried out in 1974, and will be analyzed in 1975 as part of this program.

Agency

Canadian Wildlife Service (Sample collection for Lake Michigan to be carried out by either the U.S. Fish and Wildlife Service or the University of Wisconsin).

Project Costs

Refer to Table 21.

Field collections were carried out in 1974 and will be analyzed in 1975 as part of this program.

Agency

Canadian Wildlife Service (Sample collection for Lake Michigan to be carried out by either the U.S. Fish and Wildlife Service or the University of Wisconsin).

Project Costs

Refer to Table 21.

BIBLIOGRAPHY

The following listing of reports indicates material presented by the members of the Subcommittee for use by the Subcommittee or as a response to information requests made to the Subcommittee. In addition, reports which have been utilized by the Subcommittee in the writing of the Annual Report have also been included.

This list is not a complete identification of reports placed on file at the Regional Office by the agencies represented on the Surveillance Subcomittee.

SURVEILLANCE SUBCOMMITTEE REPORTS AND REPORTS SUBMITTED ON BEHALF OF THE SUBCOMMITTEE FOR THE ANNUAL REPORT 1974 TO BE MAINTAINED ON FILE AT THE REGIONAL OFFICE

1. Problem Areas
   - 1.1 Lake Ontario, Lake Erie - CCIW
   - 1.2 Great Lakes System - MOE
   - 1.3 Lake Superior - Minnesota Pollution Control Agency
   - 1.4 Lake Superior, Lake Michigan - Wisconsin DNR.
   - 1.5 Michigan Shoreline and Detroit River - Michigan DNR.
   - 1.6 Lake Erie - Ohio EPA
   - 1.7 Lake Erie - Pennsylvania
   - 1.8 Niagara River, Lake Ontario, St. Lawrence River - New York DEC.

2. Significant Tributaries in the Great Lakes System Identified by all jurisdictions.

3. General Assessments
   - 3.1 Lake Ontario - CCIW
   - 3.2 Thunder Bay, St. Marys River - MOE
   - 3.3 Lake Superior - Minnesota PCA
   - 3.4 Lake Superior, Lake Michigan - Wisconsin DNR
   - 3.5 Michigan Shoreline - Michigan DNR
   - 3.6 Intake Data - Indiana Stream Pollution Control Board
   - 3.7 Water Pollution Investigation: Calumet area of Lake Michigan. ITT Research Institute. Great Lakes Initiative Contract Program, U.S. EPA Region V. Oct., 1974.
   - 3.8 Water Pollution Investigation: Duluth-Superior Area. Midwest Research Institute. Great Lake Initiative Contract Program, U.S. EPA Region V. Oct., 1974.

3.9 Saginaw Bay: An Evaluation of Existing and Historical Conditions. The University of Michigan Great Lakes Resource Management Program. Great Lakes Initiative Contract Program, U.S. EPA Region V. April, 1974.

3.10 Lower Green Bay: An Evaluation of Existing and Historical Conditions. The Wisconsin Department of Natural Resources. Great Lakes Initiative Contract Program, U.S. EPA Region V. August 1974.

3.11 St. Lawrence River - CCIW

3.12 Water Quality Management Plan for Lake Ontario. West Basin - New York Department of Environmental Conservation.

3.13 Water Quality Management Plan for Niagara River, Mainstem - New York Deptartment of Environmental Conservation.

4. Detailed Assessments

4.1 Lake Erie

4.1.1 Nearshore Water Quality - MOE

4.1.2 Phytoplankton Evaluation - MOE

4.1.3 Chloride Total Phosphorus and Chlorophyll a Trends in Lake Erie - MOE

4.1.4 Effect of Detroit River on Western Basin of Lake Erie - MOE

4.1.5 Lake Erie Nutrient Control Program: An assessment of its effectiveness in controlling lake eutrophication. Progress Report - 1974 Field Season. U.S. EPA Grosse Ile.

4.1.6 Annual Report Lake Erie Nutrient Control Program: An assessment of its effectiveness in controlling eutrophication - Eastern Basin. State University College at Buffalo under EPA Grant #R-802706-1 Sept. 1974.

4.1.7 Lake Erie Study Summary for the IJC. State University College at Buffalo.

4.1.8 General Assessment of Water Quality in Ohio Lake Erie tributaries and their pollution loadings to Lake Erie - Ohio EPA.

4.1.9 Evaluation and Revision of Lake Erie Tributary Phosphorus for Water Year 1974 - Ohio EPA

4.1.10 Detailed Assessment of Water Quality in Ohio Lake Erie tributaries and their pollution loadings to Lake Erie - Ohio EPA

4.1.11 Distribution of Phytoplankton and Coliform Bacteria in the Lake Erie, March 1973 - Joint Ohio EPA - U.S. EPA Report.

4.1.12 Lake Erie Water Quality Monitoring - Erie County Dept. of Health. Erie Pa.

4.1.13 Report on Material Input to Lake Erie - Michigan DNR

4.1.14 Lake Erie Water Intake Data (Buffalo, Dunkirk, Sturgeon Point) - EPA Region II

4.1.15 Review of 1974 Lake Erie Bathing Beach Water Quality. Ohio EPA.

4.1.16 Beeton, A.M. 1963. Limnological survey of Lake Erie, 1959-1960. Great Lakes Fish. Comm. Tech. Rept. 6. 32 p.

4.1.17 Burns, N.M. and Curtis Ross. 1972. Project Hypo. Canada Centre for Inland Waters, Paper No. 6 and USEPA Tech. Rept. TS-05-71-208-24. 182 p.

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4.3 Connecting Channels

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4.3.2 Detroit River - Michigan DNR

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5. Draft Surveillance Plans

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   5.2 Niagara River - New York Dec, EPA Region II, CCIW

   5.3 Detroit River - Michigan DNR

   5.4 St. Clair and St. Marys River - MOE

   5.5 Lake Erie - Surveillance Subcommittee

   5.6 Lake St. Clair - EPA Region V

   5.7 Nearshore Proposal - MOE

   5.8 Surveillance Program for Material Loadings by Atmospheric Preceipitation - CCIW

6. Additional Reports and Publications

   6.1 Report on the Relative Magnitude of Phosphorus Loading Components to Lake Erie - CCIW

   6.2 Phosphorus Uptake and Release by Lake Ontario Sediments, Feb. 1974 - EPA

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